AN

INQUIRY

INTO THE

ORIGINAL STATE AND FORMATION

OF THE

EARTH.

BRITISH MUSEUM

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PREFACE.

AFTER ſo many volumes have been written to inveſtigate the original ſtate and formation of the earth, and the revolutions it has undergone at ſundry periods of time, it may appear preſumptuous to offer my ſentiments to the public on ſo difficult and extenſive a ſubject.

But when it is conſidered that the book of nature is open to all men, written in characters equally intelligible to all nations, and perhaps in no part of the world more ſo than in Derbyſhire, the wonder will in ſome meaſure ceaſe; ſince natural phenomena ſo plentifully abound therein, that little more is required than patience and aſſiduity to diſcover their tendency to unfold the ſubject of the enſuing pages: for amid all the apparent confuſion and diſorder of the *ſtrata*, in that mountainous country, there is nevertheleſs one conſtant invariable order in their arrangement, and of their various productions of animal, vegetable, and mineral ſubſtances, or rather the figures or impreſſions of the two former.

2 Theſe

Theſe ſingular appearances, together with the numerous craggy rocks, cliffs, mountains, ſubterraneous caverns, and many other phenomena being conſtantly preſented to my obſervation, excited my attention very early in life, to inquire into the various cauſes of them; not altogether with a view to inveſtigate the formation of the earth, but in part to obtain ſuch a competent knowledge of ſubterraneous geography, as might become ſubſervient to the purpoſes of human life, by leading mankind to the diſcovery of many valuable ſubſtances which lie concealed in the lower regions of the earth.

Such were the motives which prompted me to engage in ſubterraneous reſearches; and I flatter myſelf, that the facts I have obtained from my own obſervations, and collected from many experienced miners, may entitle the following pages to a ſerious and candid examination.

The ſeveral theories of the earth already produced, contain indeed many important truths, yet it muſt be owned that they are in general two hypothetical for an age which only admits of deductions from *facts* and the *laws of nature*.

It is not however my intention to point out the faults of other ſyſtems, but to avail myſelf of ſuch parts of them as are applicable to my own deſign, namely, *to trace appearances in nature from cauſes truly exiſtent*; *and to inquire after thoſe laws by which the Creator choſe to form the world, not thoſe by which he might have formed it, had he ſo pleaſed.*

To the above I have added ſome obſervations relative to rottenſtone; a ſubſtance accompanied with ſome ſingular and curious circumſtances, which ſeem to have been hitherto unnoticed.

I have alſo taken ſome notice relative to the origin of the *entrochi* or ſcrew-ſtones, which ſo plentifully abound in the Derbyſhire marble; being the fragments of a cruſtaceous marine animal, growing or adhering to rocks in the bottom of the ſea, as a plant. Whence it is conſidered as one of the links which unites the animal and the vegetable kingdoms.

The *encrinus* is likewiſe another ſpecies of marine animal which ſubſiſts as the former, and therefore conſidered as another link of the ſame kind. The fragments of this animal are called *aſteriæ*, or ſtar-ſtones, and like the former, were originally cruſtaceous, though now changed to a ſtony ſubſtance. The above animals being eſteemed curious parts of natural hiſtory, a plate is given to repreſent their external forms.

I have alſo given ſome account of the *ſtrata* in Flintſhire, with a ſection and table to repreſent their arrangement, in order to ſhew their conformity to the *ſtrata* accompanying coal in England.

I have likewiſe added ſome obſervations on the *ſtrata* in the north of Ireland, particularly of the Giants Cauſeway, and at Balley Caſtle. The latter having a conſiderable tendency to the diſcovery of coal, and the former to aſcertain the origin of baſaltes.

Permit me further to add, that although the enſuing Treatiſe is divided into ſeveral ſections, it is not to be conſidered as a miſcellaneous work, whoſe parts are independent of each other, but the contrary: the laſt three chapters excepted.

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CHAP. I.

Of the Age of the World. Of the Laws of Gravity, Fluidity, and Centrifugal Force. Of the Figure and Fluidity of the Earth. Of its diurnal Rotation; its Beginning; and the Mode of its firſt Exiſtence.

THE number of ages elapſed ſince the DEITY created the conſtituent parts of the earth, and aſſembled them together by the laws of univerſal gravitation, ſeems to be one of the numerous arcana in the great ſyſtem of nature, which the ſagacity of man has not hitherto been able to aſcertain with any tolerable degree of preciſion. And probably a few more ages may yet paſs away before a ſatisfactory ſolution can be given to

that

that very intereſting and important problem—notwithſtanding the rapid progreſs now made in the ſcience of natural things.

The late attempts to inveſtigate the age of the world from natural phenomena, diſcovered by ſinking a well in Italy, are truly ingenious. But I preſume it will appear in the courſe of this work, that the data on which thoſe reaſonings were founded, are ſubject to ſo much fallacy, as may render the reſult thereof inconcluſive.

Therefore, ſince it appears that the age of the world has not been philoſophically aſcertained; no phyſical lights can be borrowed from its great antiquity to found any reaſonings upon. Hence we leave the chronological hiſtory of the earth to the deciſion of future ages, and for the preſent confine our reſearches to unfold its original ſtate and formation, and the revolutions and changes it may have undergone at ſundry periods of time.

The ſeveral theories of the earth produced near a century ago, contain indeed many *important truths*. Yet it muſt be owned that the ſtate of phyſical ſcience at thoſe particular eras, neceſſarily rendered all ſuch learned attempts too hypothetical for the preſent age, which only admits of deductions from facts and the laws of nature: for having no permanent baſis to found their inquiries upon, every one thought himſelf at liberty to model the earth according to the dictates of his own imagination.

Whence aroſe as great a variety of theoretical ſyſtems as of writers, ſo contrary and diſcordant to each other, that the ſciences of *Aſtronomy*, *Geography*, and *Navigation*, were greatly embarraſſed thereby, and became every day more and more enveloped in obſcurity and darkneſs.

Such was the deplorable ſtate of thoſe ſciences till the clouds of darkneſs were happily removed by the ſagacity of the immortal Newton; who, by his ſuperior knowledge of natural ſcience, truly aſcertained the magnitude and figure of the earth, from the laws of gravity, fluidity, and centrifugal force.

That truly illuſtrious philoſopher, not pretending to be wiſe above what is written in nature, did not preſume to invent laws for the government of the world, but patiently ſought after thoſe which really exiſted in nature: being rather content with a little true knowledge, than by aſſuming to know much, run the hazard of error.

Thus he ſeems to have been led on ſtep by ſtep, aided by geometrical ſcience, till he had truly demonſtrated the *figure* and *magnitude* of the *earth*. Whence it appears that the equatorial diameter of the earth exceeds the polar diameter, upward of thirty four miles, or in the ratio of 230 to 229.

Upon that great and important truth, the ſubject of the following inquiry into the original ſtate and formation of the earth, is founded; and perhaps it is the only one yet diſcovered, whence it could have been derived.

Hence all attempts to inveſtigate the ſubject, prior to that era, were rendered chimerical, or without any foundation in the nature of things.

For although the facts are innumerable, which may ſerve to illuſtrate the original ſtate and formation of the earth, yet its oblate ſpheroidical figure, and its agreement with the laws of gravity, fluidity, and centrifugal force, are perhaps the only data on which the ſubject can be founded, and the only teſt whereby its truth can be examined.

But although the earth's oblate ſpheroidical form is an object of ſo much importance in many branches of ſcience, and particularly in tracing the hiſtory of its formation; yet ſo powerful did the influence of prejudice operate on the minds of cotemporary philoſophers in favour of preconceived opinions, that the doctrines he advanced remained totally neglected many years afterward, though founded upon the unalterable laws of nature.

However it muſt be owned, to the immortal honour of the French nation, that the Royal Academy of Sciences, ever anxious for the improvement of ſcience, took the matter into conſideration, and repreſented to their ſovereign, the great neceſſity of determining the figure and magnitude of the earth, by an actual menſuration of a degree on the meridian, near the equator, and alſo in the polar regions; in order to aſcertain the different curvatures; and from their equalities, or inequalities, to determine the magnitude and figure of the earth.

This princely and hazardous enterpriſe was undertaken in Lapland, by command of Lewis XV. and executed by Meſſrs. Maupertuis, Camus, Clairaut, and Le Monier, members of the Royal Academy of Sciences in the years 1736 and 1737: and in a few years afterward the equatorial menſurations were completed by command of the King of Spain, by Don George Juan, Don Antonia Ulloa, M. Condamine, &c. The reſult of the ſeveral menſurations was as follows, viz.

$$\left.\begin{array}{ll}\text{The earth's equatorial diameter} = & 7940,598 \\ \text{The polar diameter} = \text{ - - } & 7903,650\end{array}\right\}\text{Engliſh miles.}$$

Whence it appears, that the earth's equatorial diameter exceeds its polar diameter $36\frac{948}{1000}$ miles: a proportion which ſo nearly coincides with the reſult of Sir Iſaac's demonſtration, deduced from the laws of gravity, fluidity, and centrifugal force, that the magnitude and figure of the earth were henceforward conſidered as determined with ſufficient accuracy, for the various purpoſes of aſtronomy, geography, navigation, and natural hiſtory.

Let it be remembered that Mr. George Graham, our celebrated countryman, was principally concerned in conſtructing the apparatus employed in ſurveying the polar regions.

Having premiſed theſe matters, it may be convenient to obſerve, that in order to render the ſubſequent reaſonings familiar, to thoſe who have not previouſly conſidered the laws of gravity, fluidity, and centrifugal force, on which the ſubject altogether depends; I have therefore endeavoured to adopt ſuch propoſitions for that purpoſe alone, as may ſerve to render the work more univerſally intelligible: and therefore, as the ſubject concerns the generality of mankind, I hope my learned philoſophic readers will pardon the ſteps I have taken to obtain that deſirable end; ſince, without ſuch precaution, the work muſt have been altogether unintelligible to them.

PROPOSITION I.

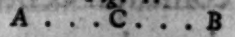
According to the univerſal law of gravitation, the conſtituent parts of all bodies mutually attract each other: whence ariſe their common centers of gravity; which ſo govern their component parts, as to cauſe all ſuch as are fluid, and do not revolve round their own axis, to aſſume ſpherical forms.

Example

Example I.

If two equal particles of matter mutually attract each other at any given diſtance, as at A and B, fig. 1. they will conſequently move with equal velocities toward each other, in the direction A C, and B C, and come into contact at the mean diſtance C: therefore the point C may be conſidered as their common center of gravity.

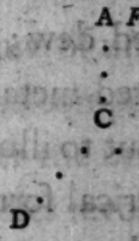
Fig. 1.



Example II.

If three equal particles of matter mutually attract each other at A B D, fig. 2. they will alſo move toward each other with equal velocities, in the direction A C, B C, D C, and come into contact at the mean diſtance C: therefore the point C may truly be conſidered as their common center of gravity.

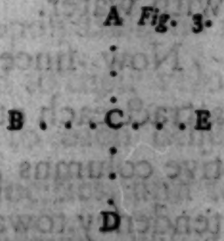
Fig. 2.



Example III.

If four equal particles of matter mutually attract each other at A B D E, fig. 3. they will likewiſe move with equal velocities in the ſeveral directions A C, B C, D C, E C, and conſequently come into contact at the mean diſtance C: therefore the point C may be conſidered as their common center of gravity.

Fig. 3.

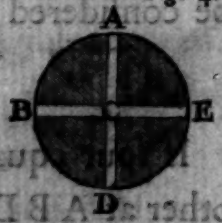


Theſe few examples may ſerve to ſhew, that an infinite number of particles may be thus aſſembled together in every poſſible direction, and thereby conſtitute a common center of gravity. Hence it evidently follows, that the center of gravity in all bodies wholly ariſes from the mutual attraction of their component parts, and not from any latent attractive principle ſituate in the center of the body itſelf.

Hence the component parts of fluid bodies, being thus aſſembled together, neceſſarily aſſume ſpherical forms: as may be obſerved in drops, or ſmall portions of water collected upon vegetables in the ſummer months, called dew; and likewiſe in ſmall portions of mercury, melted metals, &c.

But to illuſtrate the cauſe of fluid bodies, thus aſſuming ſpherical forms, more fully, let fig 4. repreſent a globe ſimilar to that of the earth, perforated from A to D, and from B to E; but not revolving round its axis. And let us ſuppoſe the perforations completely filled with water.

Fig. 4.



Now ſince the component parts of water mutually attract each other, it evidently follows, that the reſpective columns A C, B C, D C, E C, will have an equal tendency toward their common center of gravity C; conſequently their reſpective lengths will be equal: and therefore if an infinite number of perforations were thus made in every poſſible direction, and filled with water, their lengths would be equal alſo. Hence it is that fluid bodies, which do not revolve about their axis, aſſume ſpherical forms, from a mutual attraction of their component parts.

And therefore, ſince it appears that there are no other laws or principles in nature yet known, whence bodies aſſume ſpherical forms, the preſumption is great, that all bodies naturally ſpherical have been originally in a ſtate of fluidity, although they may be firm and ſolid in their preſent ſtate.

Having thus endeavoured to define the law of univerſal gravitation, together with its effects on the component parts of all bodies; we have now to conſider the univerſal laws of motion, and their effects on bodies revolving round their own axis.

PROPOSITION II.

According to the univerſal laws of motion, the conſtituent parts of all bodies which revolve upon their own axis, acquire centrifugal force proportional to their velocities: therefore, as their diſtances are to each other from their axis of motion, ſo are their velocities, and ſo are their centrifugal forces. Newton's Princip. vol. 1, prop. 4, ſection 2.

Example I.

Let fig. 1. plate III. repreſent an equatorial ſection of a globe, or the plane of its equator, revolving with any given velocity, or performing any number of rotations in the ſpace of *one minute*, *one hour*, *one day*, or *one year*. And let us ſuppoſe its radius divided into ſix equal parts, by means of the concentric circles 1, 2, 3, 4, 5, 6.

Now ſince the circumferences of all circles are to each other as their reſpective diameters; it will evidently follow, that the velocity, and centrifugal force, of the particles contained in each circle, will increaſe according to the ſeveral diſtances from their axis, or center of motion A. Again,

Example II.

Let fig. 2, plate III, repreſent the polar ſection of a globe, A A its axis, and E E its equator, and let us ſuppoſe its equatorial radius divided into ſix equal parts, as repreſented by the lines 1, 2, 3, 4, 5, 6, running parallel to the axis A A. Hence it appears, according to the former diagram, that the velocity and centrifugal force of the particles contained in each line will increaſe according to their reſpective diſtances from their axis of motion A A.

Now ſince the velocity, and centrifugal force, of the particles contained in the axis A A, is nothing; and that the velocity and centrifugal force of the particles contained in the lines 1, 2, 3, 4, 5, 6, increaſe according to their reſpective diſtances from their axis of motion A A, it evidently follows, that the equilibrium of gravitation is deſtroyed in all revolving bodies: and therefore ſuch as turn round their axis in a ſtate of fluidity, will neceſſarily depart from a ſpherical form, and aſſume that of an oblate ſpheroid, whoſe equatorial diameters will exceed their polar diameters, in a certain ratio, according to the *ſquare of their periodical rotations.*

Such are the conſequences neceſſarily ariſing from the laws of gravity, fluidity, and centrifugal force, combined: and therefore ſince there are no other laws or principles in nature yet known, whence bodies can naturally acquire oblate ſpheroidical forms; may we not thence conclude, that all oblate ſpheroidical bodies acquired thoſe particular forms, by revolving round their own axis in a ſtate of fluidity, although they may be *firm and ſolid in their preſent ſtate.*

Therefore ſince it is a truth univerſally known, that the figure of the earth is an oblate ſpheroid, perfectly coinciding with the laws of gravity, fluidity, and centrifugal force; may we not thence infer that the earth acquired its oblate ſpheroidical form by revolving round its axis, in a ſtate of fluidity; although it is firm and ſolid in its preſent ſtate.

Now ſince the figure of the earth ſo perfectly coincides with the unalterable laws of nature, the preſumption is great, that its diurnal rotation has not ſuffered any change or variation, but has performed equal rotations in equal times from the *moment of its firſt exiſtence, to the preſent era.*

Whence it appears highly probable, that as the diurnal revolutions of the earth have been performed in equal periods of time, in all preceding ages; by parity of reaſon we may preſume, that *its annual revolutions* have alſo been performed in *equal periods of time*; and if ſo, the menſurations of time have been invariably alike from the beginning of the world to the preſent era.

Having endeavoured to prove from the laws of nature, that the earth was originally in a ſtate of *fluidity*; and likewiſe that the length of days and years have been equable in all preceding ages; let us take into conſideration the cauſe of its fluid ſtate; and whether it is more probable that the earth had a beginning, or that it has exiſted from eternity, as ſome have imagined.

It will be readily granted, that if the earth was created, it muſt have been brought into exiſtence either in a ſolid, or in a fluid ſtate: if we ſuppoſe the former, it muſt have been diſſolved, and this by an univerſal diſſolvent principle: therefore, ſince no ſuch principle is yet known to exiſt in nature, it ſeems much more reaſonable

ble to conclude, that the fluidity of the earth was owing to the firſt aſſemblage of its component parts, than to any ſubſequent ſolution.

Therefore it is more probable that the earth had a beginning, than that it has exiſted eternally, as ſome writers have ſuppoſed; though the period of its paſt exiſtence has not hitherto been philoſophically aſcertained.

As ſome further teſtimony of the preceding concluſions with reſpect to the fluidity of the earth, the equability of its diurnal rotation, the commencement of its firſt exiſtence, &c. it may not be improper to enumerate the following inſtances with reſpect to the planetary ſyſtem.

Sir Iſaac Newton has obſerved, Propoſition 18, Theorem 16. "That the axis of the planets are leſs than "the diameters drawn perpendicular to the axis." . . .

"The equal gravitation of the parts on all ſides, would "give a ſpherical figure to the planets, if it were not for "their diurnal revolutions in a circle. By that circular "motion it comes to paſs that the parts receding from "their axis, endeavour to aſcend about the equator; "and therefore if the matter is in a fluid ſtate, by its aſcent toward the equator it will enlarge the diameter "there, and by its deſcent toward the poles it will "ſhorten the axis.

"So the diameter of Jupiter (by the concurring obſer"vations of aſtronomers) is found ſhorter between pole "and pole, than from eaſt to weſt. And by the ſame

" argument, if our earth was not higher about the equa-" tor than at the poles, the ſea would ſubſide about the " poles, and, riſing about the equator, would lay all " things there under water."

And according to the obſervations of Mr. Herſchel on the planet Mars, it appears that its equatorial diameter is greater than its polar diameter.

Such phenomena therefore, ſeem to ſhew, that all the planetary ſyſtem is equally ſubject to the ſame laws of gravity, and centrifugal force with the earth: and alſo that the former as well as the latter were originally in a ſtate of fluidity, and derived their oblate ſpheroidical forms from the ſame principles.

Hence we may conclude, that the fluidity of the planets was not owing to any diſſolvent principle, but to the firſt aſſemblage of their component parts: whence it appears that they were alſo brought into exiſtence at ſome remote period of time, and have not exiſted from all eternity, as might have been imagined.

Whether the above inferences are concluſive, or not, muſt be ſubmitted to the judgment of the candid reader; however, ſince we are not conſcious that any part thereof is in any degree repugnant to the laws and operations of nature, we ſhall therefore proceed to conſider the conſequences ariſing from the fluidity of the earth, in the following chapter.

CHAP. II.

Of the chaotic State of the Earth. Of its not being habitable. Of the Antiquity of geometrical and philoſophical Sciences.

ACCORDING to the reſult of the preceding deductions, the globe which we now inhabit, was originally in a ſtate of fluidity, owing to the firſt aſſemblage of its component parts, and the infinite diviſibility of matter. Our preſent object therefore is to inveſtigate the conſequences neceſſarily ariſing from that particular ſtate and condition of the earth.

The fluidity of the earth manifeſtly implies, that the particles of matter which now compoſe the ſtrata and all other ſolid bodies, were not originally united, combined, or fixed by coheſion, but were actually in a ſtate of ſeparation, as particles of ſugar, or ſalt, diſſolved and ſuſpended in water.

It is a truth univerſally known, that the component parts of the moſt denſe bodies become ſuſpended in what ever menſtrua they are diſſolved: as for inſtance, the particles of gold in aqua regia, ſilver in aqua fortis, ſalts in water, and water in air. Nay we may likewiſe add, that the component parts of mercury in the act of diſtillation, become ſuſpended in air, notwithſtanding the ſpecific gravity of the former is to that of the latter, as 11000 to 1, nearly. Such therefore are the conſequences neceſſarily ariſing from the infinite diviſibility of matter, none being heavier or lighter than another, when thus reduced to their original elementary principles.

Whence it appears, that when the component parts of the earth were firſt aſſembled together, they were in a ſtate of uniform ſuſpenſion, and ſeem to have compoſed one general undivided maſs or pulp, of equal conſiſtence and ſameneſs in every part, from its ſurface to its center; and therefore conſtituted that particular ſtate and condition of the earth, which the ancients have named chaos, and have deſcribed as a confuſed maſs or pulp, compoſed of all the various elementary principles blended together, and *without form and void.*—That is to ſay, the chaos had not yet acquired an oblate ſpheroidical form, and the component parts thereof were void of that arrangement which conſtitutes bodies of different denominations; as *air*, *water*, *ſtone*, *minerals*, &c. but the whole maſs compounded of the various elementary principles, blended together in one confuſed heap.

Conſequently the chaotic ſtate of the earth was totally unfit for animal or vegetable life; and therefore it would be extremely abſurd, and repugnant to the laws of nature, to ſuppoſe that any ſuch bodies were created before the chaos was become ſuitable to the nature of their ex-

exiſtence. And this idea, concerning the primitive ſtate of the earth, not only coincides with the *Moſaic account of the creation*, but likewiſe with the opinions of the moſt ancient philoſophers, hiſtorians, and poets, who have roundly aſſerted, but not proved the doctrines they have advanced; for, it does not appear that their opinions were the reſult of phyſical deductions, but they rather ſeem to have been borrowed from popular opinions, which prevailed in the ſeveral ages wherein theſe authors lived. For inſtance,

“ The Phenicians believed that the earth was origi-
“ nally a fluid maſs or pulp: and the ſame opinion
“ is well known to have been ſo ſtrongly impreſſed on
“ the minds of the Egyptians, that one of their kings,
“ Ptolemy, the ſon of Lagos, is ſaid to have erected a
“ temple in commemoration of it, built of all the vari-
“ ous kinds of ſtones; in which was placed an altar of
“ divers colours, and a ſtatue of the god Serapis, com-
“ poſed of all the different kinds of metals mixed toge-
“ ther, alluding to the confuſion of elements.” See Hiſtoire de la Philoſophie, par Deſlandes.

Such were the doctrines maintained by the ancients concerning the original ſtate of the earth; but it does not appear whether the Phenicians or the Egyptians were the original authors of thoſe tenets, or whether they were borrowed from the learning of more ancient nations.

Thus much however we may venture to aſſert, namely, that ſince it appears that the earth in its chaotic ſtate, was not habitable; we may thence conclude, it was not inhabited: and therefore ſuch opinions could not have been originally derived from obſervation. Whence it neceſſarily follows that ſuch doctrines were originally the reſult either of revelation, or of reaſon. Now if from the former, all phyſical inquiry ceaſes; but if from the latter, or from philoſophical deductions, may we not thence conclude, that ſuch opinions were originally derived from the laws of gravity, fluidity, and centrifugal force; ſince there are no other principles in nature yet known, from whence ſuch ideas could have been fully and truly obtained; though there are many corroborating teſtimonies which evidently ſhew, that the earth was originally in a ſtate of fluidity; and therefore the preſumption is great, that the Newtonian philoſophy was familiarly known in remote antiquity, poſſibly much anterior to the Phenician or Egyptian nations, though totally loſt, and afterward revived again by Sir Iſaac Newton.

Hence we conſider the opinions of the ancients concerning the chaotic ſtate of the earth, as the ſcraps or fragments of ancient learning.

It is a common obſervation, that arts ever expire with ruined empires, conquered by ſavage barbarians. And we have likewiſe ſome inſtances upon record of great revolutions ariſing from natural cauſes, in the early ages of the world; namely by *ſubterraneous convulſions*, *deluges*, &c. whereby the ſucceeding race of people were deprived of the advantage ariſing from the preceding ſtate of arts, as much as if no ſuch arts had ever exiſted.

The obſervations of Lord Bacon ſeem to corroborate the preceding ideas, relative to the antiquity of ſcience. In his preface on the Wiſdom of the Ancients, he writes thus:

" Above all things this prevails moſt with me, and is " of ſingular moment; many of theſe fables do not ſeem " to have been invented by the authors by whom they " are related and celebrated, as Homer, Heſiod, and " others; for if it were ſo, that they took beginning in " that age, and by thoſe authors by whom they are delivered and brought to our hands, I imagine there " could be no great or high matter expected, or ſuppoſed to proceed from them, in reſpect to thoſe originals. But if with attention we conſider the matter, " it will appear that they were delivered and related as " things formerly believed and received, and not as newly invented, and offered to us. Beſides, ſeeing they " are diverſly related by writers that lived nearly about " one and the ſame time, we may eaſily perceive that

" they were common things, derived from precedent
" memorials; and that they became various by reaſon of
" the divers ornaments beſtowed on them by particular
" relations. And the conſideration of this muſt needs
" increaſe in us a great opinion of them, as not being
" accounted either the effects of the times, or inven-
" tions of the poets, but as ſacred relicks, or abſtracted
" airs of better times, which by tradition from more
" ancient nations, fell into the trumpets and flutes of
" the Grecians."

The obſervations of this great philoſopher on the wiſdom of the ancients, ſeem to coincide with the preceding ideas, relative to the ſtate of learning and ſcience in remote antiquity.—that ſeveral branches thereof were brought to a conſiderable degree of perfection, in ages much anterior to any hiſtory or tradition now extant; but have become ſo far mutilated by length of time and ſundry occurrences, that only a few ſcraps thereof remain, as the veſtiges of ancient ſciences.

Indeed the remains of thoſe ancient buildings, the Egyptian pyramids, and the ruins of Palmira and Balbec, are ſo many inconteſtible evidences of the antiquity and perfection of arts and ſciences. The former being planned and executed on the beſt geometrical principles for duration; and the latter are ſo elegantly planned and executed, that they are eſteemed as ſtandards in the ſcience of architecture in the preſent age. The former are ſaid to have been erected much beyond the reach of hiſtory: and the latter are ſaid to be of ſuch great antiquity, as to render the era of their erection very obſcure and doubtful.

Now it appears to be a matter worthy conſideration, that theſe noble magnificent edifices are conſtructed upon geometrical principles; ſince it will be readily granted, that the ſcience of geometry was known, and brought to a conſiderable degree of perfection, before it was applied to the conſtruction of theſe buildings: therefore, ſince the exiſtence of the ſcience of geometry, and its application in the above inſtances, are ſo very obvious, may we not reaſonably preſume, that the ſame ſcientifical principles might have been applied in the inveſtigation of philoſophical ſubjects: and particularly in demonſtrating the magnitude and figure of the earth, from the laws of gravity, fluidity, and centrifugal force. Indeed when we conſider the coincidence ariſing between the reſult of phyſical reaſoning, and the doctrines advanced by the Phenicians and the Egyptians, we may deem it as a certain truth, that thoſe doctrines were originally the reſult of philoſophical reaſonings, and were not the invention of poets: for in the firſt place, they could not have been obtained by tradition alone, as mankind was not an eye witneſs of the chaotic ſtate of the earth; and in the ſecond place, there are no other principles in nature yet known, whence ſuch doctrines could have been derived.

Hence we conclude that the ſciences of geometry and philoſophy were known in ages much anterior to hiſtory or tradition: in favour of which opinion ſome other inſtances will appear in the courſe of this work.

But theſe conſiderations are rather a digreſſion from the ſubject before us. Therefore we ſhall now return to the chaotic ſtate of the earth, and endeavour to aſcertain whether its component parts were created *homogeneous* or *heterogeneous*, as being a neceſſary preliminary to the enſuing reſearches.

CHAP. III.

Of the component parts of the Chaos; whether homogeneous or heterogeneous.

HAVING endeavoured to ſhew, that the terraqueous globe was originally *a fluid, chaotic, undivided maſs*, compoſed of all things blended together, ſo as to render it totally unfit for animal or vegetable life, we have now to conſider, whether its *component parts were homogeneous* or *heterogeneous*, as a neceſſary ſtep toward a general inveſtigation of the ſubject.

If the component parts of the chaos were created homogeneous, or endued with one univerſal quality, affinity, or ſameneſs, we might thence conclude, that according to the immutable laws of nature, they would neceſſarily have remained of one univerſal denomination to the end of time: and ſo, in like manner, if they were created heterogeneous, or endued with a variety of principles, or laws of elective attraction, they would neceſſarily have remained of different qualities or affinities to the end of time.

Theſe axioms being granted, it remains now to aſcertain, whether the component parts of the earth are homogeneous, or heterogeneous: for whatever qualities or affinities are found to exiſt in the particles of matter, we may thence infer, from the unalterable laws of nature, that the component parts of the chaos were endued with ſimilar principles, or laws of attraction.

Now, no truth in nature is more obvious, than that the component parts of the earth are endued with a variety of principles, or laws of elective attraction; though they are equally and univerſally governed by one and the ſame law of gravitation.

But theſe are truths indeed, more known to chymiſts than to many other claſſes of mankind; and therefore ſome account thereof becomes requiſite, in order to ſhew the principles on which the arrangement of matter into various ſubſtances depend.

The celebrated chymiſt, M. Macquer, has laid down the laws of affinity, or elective attraction, as ſo many propoſitions, neceſſary to the inveſtigation of many natural phenomena, or the effects produced by different combinations of matter: upon which principles alone, the ſeparation of the chaos into air, water, &c. is wholly founded. This eminent author obſerves, in his Elements of Chymiſtry, vol. 1. p. 12, that,

"All experiments hitherto made concur with daily "obſervation to prove that different bodies, whether "principles or compounds, have ſuch a mutual confor-"mity, relation, affinity, or attraction, if you will call "it ſo, as diſpoſes ſome of them to join and unite toge-"ther, while they are incapable of contracting any "union with others. This effect, whatever be its cauſe, "will enable us to account for, and connect together, "all the phenomena that chymiſtry produces. The "nature of this univerſal affection of matter is diſtinctly "laid down in the following propoſitions.

"Firſt, If one ſubſtance has any affinity or confor-"mity with another, the two will unite together, and "form one compound.

"Secondly, It may be laid down as a general rule, "that all ſimilar ſubſtances have an affinity with each "other, and are conſequently diſpoſed to unite; as wa-"ter with water, earth with earth, &c.

“ Thirdly, Subſtances that unite together, loſe ſome “ of their ſeparate properties; and the compounds reſult- “ ing from their union partake of the properties of thoſe “ ſubſtances, which ſerve as their principles.

“ Fourthly, The ſimpler any ſubſtances are, the more “ perceptible and conſiderable are their affinities: whence “ it follows, that the leſs bodies are compounded, the “ more difficult it is to analyze them; that is, to “ ſeparate from each other the principles of which “ they conſiſt.

“ Fifthly, If a body conſiſts of two ſubſtances, and to “ this compound be preſented a third ſubſtance, that “ has no affinity at all with one of the two primary ſub- “ ſtances aforeſaid, but has a greater affinity to the other “ than thoſe two ſubſtances have to each other, there “ will enſue a decompoſition, and a new union: that is, “ the third ſubſtance will ſeparate the two compounding “ ſubſtances from each other, coaleſce with that which “ has an affinity with it, form therewith a new combi- “ nation, and diſengage the other, which will then be “ left at liberty, and ſuch as it was before it had con- “ tracted any union.

“ Sixthly, It happens ſometimes that when a third “ ſubſtance is preſented to a body conſiſting of two ſub- “ ſtances, no decompoſition follows; but the two com- “ pounding ſubſtances, without quitting each other,

" unite with the ſubſtance preſented to them, and form " a compoſition of three principles: and this comes to " paſs when that third ſubſtance has an equal, or nearly " equal, affinity with each of the compounding ſub- " ſtances. The ſame thing may alſo happen even when " the third ſubſtance hath no affinity but with one of the " compound ſubſtances only. To produce ſuch an " effect, it is ſufficient that one of the two compounding " ſubſtances have to the third body a relation equal, or " nearly equal, to that which it has to the other com- " pounding ſubſtance with which it is already combined. " Thence it follows, that two ſubſtances, which, when " apart from all others, are incapable of contracting any " union, may be rendered capable of incorporating to- " gether in ſome meaſure, and becoming parts of the " ſame compound, by combining with a third ſubſtance " with which each of them has an equal affinity.

" Seventhly, A body, which of itſelf cannot decom- " poſe a compound conſiſting of two ſubſtances, becauſe, " as we juſt now ſaid, they have a greater affinity with " each other than it has with either of them, becomes " nevertheleſs capable of ſeparating the two by uniting " with one of them, when it is itſelf combined with " another body, having a degree of affinity with that one " ſufficient to compenſate its own want thereof. In " that caſe, there are two affinities, and thence enſues a " double decompoſition and a double combination."

Such are the conſtant invariable laws impreſſed upon matter of all denominations, now exiſting, whether ſolids or fluids. And we have much reaſon to ſuppoſe, that upon the various combinations thereof, all the phenomena in the viſible parts of the material world actually ariſe.

Hence we may conclude, that ſince the laws of nature are unalterable, the preſumption is great, that the component parts of the chaos were *heterogeneous* or *endued with* the ſame variety of elementary principles, or laws of elective attraction, as above repreſented; notwithſtanding they are equally governed by one and the ſame univerſal law of gravitation.

CHAP. IV.

Of the Chaos, whether inſtantaneouſly or progreſſively formed into a habitable World.

IN the preceding chapters we have endeavoured to ſhew, that the earth was originally a fluid, chaotic, heterogeneous maſs, totally unfit for animal or vegetable life; therefore it becomes requiſite to inquire, whether the chaos was inſtantaneouſly or progreſſively formed into a habitable world.

No one will preſume to doubt but that the ſame Being who created matter, and governs it by immutable laws, might have formed the chaos into a habitable world in a moment of time, had he ſo pleaſed.

It is not however the buſineſs of philoſophy to inquire what the Deity might have done, with reſpect to the formation of the earth; but to diſcover, if poſſible, by what mode he is pleaſed to act, in the continuation and government of his works: for by whatever mode the operations of nature are continually carried on, we may thence conclude, that by the ſame mode the chaos was formed into a habitable world.

A little obſervation will ſatisfy the moſt inquiſitive mind, that the operations of nature are progreſſive in the production of animal, vegetable, and mineral ſubſtances. The plants and fruits of the earth riſe to maturity from their ſeeds, or firſt principles, in a regular uniform progreſſion: and we have many obvious inſtances of the progreſſive formation of ſtone, and minerals, in the bowels of the earth; for inſtance,

1. The ſprings at Matlock Bath in Derbyſhire, though extremely pellucid and friendly to the human conſtitution, are nevertheleſs plentifully ſaturated with calcarious matter, which readily adheres to vegetables and other ſubſtances, immerſed in their ſtreams, and thus, by a conſtant accretion, large maſſes of ſtone are gradually

formed. The banks on which the bathing houſes ſtand, and likewiſe the buildings themſelves, are moſtly compoſed of ſuch materials.

2. The limeſtone *ſtrata* in Derbyſhire, and in many other parts of England, abound with the *exuviæ* of marine animals, or the impreſſions of them, in the ſolid ſubſtance of the ſtone; and we have likewiſe ſeveral inſtances related by authors, of the bones of terreſtrial animals, and alſo of wood, having been found inveloped in *ſtrata* of ſtone.

3. A complete human ſkeleton, with Britiſh beads, chains, iron rings, braſs bits of bridles, &c. were dug up in a ſtone quarry, near the Earl of Widrington's ſeat, at Blankney in Lincolnſhire.

4. Human bones and armour, with Roman coin, *fibulæ*, &c. were found in a ſtonepit, in the park at Hunſtanton in Norfolk; ſuppoſed to have been buried in the earth after a battle. Baddan's Abridg. Philoſ. Tranſ. vol. vi. p. 444.

5. In the mountains of Canne, half a league from Meaſtrick, the *vertebræ* of a crocodile, thirty feet long, were found in a *ſtratum* of ſandſtone, well preſerved.

6. The remains of a crocodile were alſo found in a *ſtratum* of ſtone at Blenheim, the ſeat of the Duke of Marlborough; and are now in the poſſeſſion of the learned Mr. Bryant.

7. The beds of argillaceous ſtone, &c. incumbent on coal, contain a great variety of figured foſſils, repreſenting different ſpecies of the vegetable creation.

8. The conſtant accumulation of mineral ſubſtances, in the caverns and fiſſures of the limeſtone *ſtrata*, is no leſs evident than the ſtony concretions. And

9. The ſtalactites which hang from their lofty roofs, as icicles from the eves of houſes, are continually increaſing in number end magnitude; and the bottoms and ſides of the caverns are daily incruſting with ſpar, and other mineral ſubſtances. Such operations of nature may be conveniently obſerved in thoſe celebrated caverns called Pool's Hole, near Buxton, and Peak Hole, at Caſtleton.

10. Many of theſe ſubterraneous caverns and fiſſures are alſo incruſted with alternate *laminæ* of ſpar, lead ore, zinc ore, pyrites, fluor, and other ſubſtances; and in theſe receſſes they cryſtallize in various forms, peculiar to the nature, or affinities of their component parts.

Were we allowed to reaſon upon the general cauſe of theſe wonderful appearances, we ſhould be apt to conclude from the various circumſtances accompanying them, that they ariſe from water filtrating ſlowly through the incumbent *ſtrata*; and taking up in its paſſage a variety of mineral ſubſtances, and becoming thus ſaturated with metallic particles, gradually exuding on the ſurface of the caverns and fiſſures, in a quieſcent ſtate, the aqueous particles evaporate, and leave the mineral ſubſtances to unite according to their affinities.

Hence a variety of mineral ſubſtances are daily forming in ſelect bodies, though in one general maſs; one part thereof conſiſting of ſpar, another of fluor, lead ore, the ore of zinc, cryſtal, or whatever ſubſtances may happen to have been collected by the water, in its paſſage through the incumbent *ſtrata*.

Such cryſtallization however depends in ſome meaſure on the quantity of water exuded through the pores of the ſtone; for if the quantity exuded exceeds the quantity evaporated, ſtalactites are produced in one inſtance, and tubes in another.

The latter are thus formed. If a drop of water hangs from the roof, and remains ſuſpended, but nearly dropping, the aqueous particles evaporating from the ſurface thereof ſooner than from its interior parts, the mineral particles unite on the ſurface of the drop, while the interior part remains fluid; the water thus detained is continually increaſing, and gradually extends in length downward. The proceſs, thus going on, frequently forms tubes, one or two feet in length, and about one tenth of an inch diameter.

Such phenomena as above recited, evidently ſhew that all beds of ſtone were originally in a ſtate of fluidity, to receive the bodies thus entombed, and therefore ſerve to corroborate the concluſions we have drawn in Chap. I. And they, likewiſe, together with the mineral productions, abundantly teſtify that the operations of nature are progreſſive in all the viſible parts of the material world.

Whence it appears that the chaos was not *inſtantaneouſly*, but *progreſſively* formed intoa habitable world.

CHAP. V.

Of the Separation of the Chaos into ſelect Bodies of various Denominations, viz. Air, Water, Earth, and other Subſtances.

HAVING premiſed the general laws or principles beſtowed upon matter, whereby the material world is conſtantly and invariably governed; and having likewiſe attempted to inveſtigate the original ſtate of the earth, or the mode of its firſt exiſtence, its beginning, and the equability of its annual and diurnal revolutions: we ſhall endeavour to trace the progreſſive operations of nature in the ſeparation of the chaotic maſs into air, water, earth, and other ſelect ſubſtances, as preparatory ſteps toward unfolding the formation of the chaos into a habitable world.

The firſt operation which apparently preſents itſelf to our conſideration, is the figure of the earth; for according to propoſition the ſecond, page 9, the fluid maſs no ſooner began to revolve upon its axis, than its component parts began to recede from their axis of motion, and thus continued till the earth had acquired its preſent oblate ſpheroidical form. The two forces then became equally balanced, and the equilibrium of gravitation reſtored.

The component parts of the chaos being thus arrived at a ſtate of reſt with reſpect to the effects ariſing from gravity, and centrifugal force, began more immediately to act according to their affinities, or the laws of elective attraction; for according to propoſition the ſecond, page 24, particles of a ſimilar nature attract each other more powerfully than thoſe of contrary affinity, or quality.

But to illuſtrate this doctrine, let us ſuppoſe that a variety of ſalts are diſſolved in one and the ſame menſtruum, or maſs of water; it will come to paſs, that particles of a ſimilar nature will unite, and form the ſame ſelect ſubſtances as they were before ſolution; provided the menſtruum remains perfectly quieſcent: for, on the contrary, no union will take place among them; as the particles of the ſeveral ſalts will remain in a ſtate of ſolution, equally diffuſed throughout the whole maſs of water: reſt being ſo eſſentially neceſſary to the union of ſimilar ſubſtances.

Theſe matters being duly conſidered, it will evidently appear, that the component parts of the chaos no ſooner became quieſcent, than ſimilar particles began to unite, and compoſe bodies of various denominations; that is to ſay, the particles of *air* united with thoſe of *air*, thoſe of *water* with *water*, and thoſe of *earth* with *earth*; and with their *union commenced their ſpecific gravities*.

The uniform ſuſpenſion of the component parts, which had hitherto prevailed throughout the chaotic maſs, being thus deſtroyed by the union of ſimilar ſubſtances, bodies of the greateſt denſity began their approach toward the center of gravity, and thoſe of the greateſt levity aſcended toward the ſurface.

Thus apparently commenced the ſeparation of the chaos into *air*, *water*, *earth*, and other ſelect bodies.

Now ſince the ſpecific gravity of air, is to that of water, nearly as 1 to 800; therefore, according to the laws of ſtatics, the former became freed from the general maſs, in a like proportion of time, ſooner than the latter, and ſurrounded the terraqueous globe with a *muddy impure atmoſphere*.

The proceſs of ſeparation ſtill goes on, and the earth conſolidates every day more and more toward its center; and its ſurface became gradually covered more and more with water, until the ſea prevailed univerſally over the earth.

Thus by the union of ſimilar particles, the atmoſphere and the ocean ſeem to have been ſeparated from the general maſs, in ſucceſſive periods of time; and were progreſſively freed from all impurities, and rendered perfectly *fit for animal life*.

To the laws of elective attraction we may likewiſe aſcribe that ſameneſs of quality which prevails in *ſtrata* of different denominations, as calcarious, argillaceous, &c. and alſo the aſſemblage of all other particles into ſelect bodies of metals, minerals, ſalts, talcs, ſpars, fluors, cryſtals, diamonds, rubies, amethyſts, &c. and likewiſe many other phenomena in the natural world.

Having thus endeavoured to trace the operations of nature in ſeparating the component parts of the chaos, and arranging them into ſelect claſſes of different denominations; it becomes a matter of ſome importance to conſider, that as the ſun is the common center of gravity, or one of the great governing principles in the planetary ſyſtem; we may thence infer that the governing body was at leaſt coeval with the bodies governed.

Therefore as the chaos revolved upon its axis during the *period of its ſeparation into air and water*, and their becoming freed from all groſs matter and rendered fit for animal life, we may thence reaſonably infer, that as the atmoſphere was progreſſively freed from heterogeneous ſubſtances, light and heat gradually increaſed every day more and more, until the ſun became viſible in the firmament, and ſhone with its full luſtre and brightneſs upon the face of the new-formed globe.

Such appearing to have been the natural order and progreſſion of theſe things, the preſumption is great, that light, and likewiſe ſeveral days and nights preceded the ſun's appearance in the firmament; which ſeems to corroborate the ſcripture account of the creation; namely, that of ſeveral days and nights preceding the creation of the ſun and moon, or their becoming viſible on the fourth day of creation. How far the reſult of this reaſoning may ſerve to illuſtrate the Moſaic account, we readily ſubmit to the candid reader.

Before we conclude this chapter, it may not be unworthy of the reader's attention to conſider in what particular part of the chaos the laws of elective attraction began firſt to operate.

We have already obſerved that quieſcency is an eſſential requiſite to the union of ſimilar ſubſtances; and therefore as the central parts of the chaos were more quieſcent than thoſe nearer to the ſurface, we may thence infer, that the laws of affinity began to operate ſooner in the central parts, than in thoſe near the ſurface: therefore it ſeems repugnant to the laws of nature, that the central part of the earth ſhould conſiſt of water only, and the exterior part of a ſhell or cruſt, as ſome have imagined.

CHAP. VI.

Of the Formation of the Primitive Iſlands.

HAVING endeavoured to trace the progreſſive operations of nature in the formation of the atmoſphere and ocean, and in rendering them perfectly pure and fit for animal life; we have now to conſider the formation of the primitive iſlands for the reception of the terreſtrial animal and vegetable kingdoms.

According to the reſult of the preceding chapter, the ſea univerſally prevailed over the earth: therefore in order to inveſtigate the origin of the primitive iſlands, let us ſuppoſe for the preſent, that during the ſeparation of the atmoſphere and the ocean from the chaotic maſs, the earth was perfectly free from the *attractive influence of all other bodies*; or that nothing interfered with the uniform law of its own gravitation.

Under ſuch circumſtances it will neceſſarily follow, that as the chaos was an uniform pulp, the ſolids would equally ſubſide from every part of its ſurface, and conſequently become equally covered with water.

On the contrary, if the ſun and the moon were coeval with the earth, as before ſuggeſted, their attractive influence would neceſſarily interfere with the regular uniform ſubſiding of the ſolids: for as the ſeparation of the ſolids and fluids increaſed, ſo in like manner the tides would increaſe, and remove the ſolids from place to place without any order or regularity.

Hence the ſea became unequally deep; and thoſe inequalities daily increaſing, in proceſs of time dry land appeared, and divided the ſea, which had hitherto prevailed univerſally over the earth.

Such we conceive to have been the conſequences neceſſarily ariſing from the chaotic ſtate of the earth, and its coexiſtence with the ſun and the moon.

Whence we may reaſonably infer, that the primitive iſlands were formed by the flux and reflux of the tides, as ſand banks are daily forming in the ſea; and conſequently could not acquire any conſiderable extent, or elevation, compared to the mountains and continents now exiſting in the preſent ſtate of the earth; but as ſo many uniform protuberances gradually aſcending from the deep.—No craggy rocks, ſtupendous cliffs, or impending ſhores were then exiſting, to curb the boiſterous waves; but the whole ſurface of the earth was ſmooth, even, and uniform; the *ſtrata* not yet arranged, and minerals only exiſted in their elementary principles.

Such we preſume was the ſtate of the primitive iſlands, which in proceſs of time became firm and dry, and fit for the reception of the animal and vegetable kingdoms.

Having thus endeavoured to trace the operations of nature in forming the chaos into a habitable world; we cannot paſs over in ſilence the great analogy which prevails between the *Moſaic account of the creation, and the reſult of the preceding deductions:* for the ſame ſeries of truths which are aſſerted in the former, are hereby deduced from the laws and operations of nature.

From this obvious agreement between revelation and reaſon, in ſo many eſſential points, we may reaſonably infer, that they both flow from the ſame fountain, and therefore can never operate in contradiction to each other. Conſequently, by which ever means the ſame truths are brought to light, be it by revelation or reaſon, they will perfectly coincide, and that coincidence may be conſidered as a teſtimony of the truth of each.

CHAP.

CHAP. VII.

Of the general Order or Succeſſion in which Land and Sea Animals were created. And of their Entombment in the Bowels of the Earth.

According to the preceding chapters, the atmoſphere, ſea, and land, were brought to maturity for the reception of the animal and vegetable kingdoms, in ſucceſſive periods of time. Let us therefore endeavour to aſcertain the general order or ſucceſſion in which they were ſeverally created.

This inquiry is particularly brought forward, as containing many corroborating teſtimonies relative to the preceding concluſions, with reſpect to the original ſtate and formation of the earth, and the progreſſive order in which the ſeveral elements were ſeparated from the chaos, and rendered perfectly pure and fit for animal and vegetable life.

The phenomena on which this reaſoning principally depends, are the *exuviæ* of *marine* and *terreſtrial animals entombed in the ſolid ſubſtance of ſtone*, *chalk*, *clay*, *gravel*, and *ſand*, in all parts of the world; upon mountains, in vallies, and deep receſſes of the earth, both near and remote from the ſea.

On the agreement of ſuch facts with the laws and operations of nature, the ſubject of the preſent inquiry muſt ſtand or fall: therefore much depends upon a faithful examination of the ſeveral phenomena relative to foſſil bodies. For inſtance,

1. In what ſubſtances animal and vegetable remains are found; as, in what denomination of ſtone, chalk, clay, ſand, or gravel.

2. Whether the ſhells, bones, and teeth of fiſh retain their native matter, or whether become wholly or in part changed to the ſubſtance of the *ſtrata* in which they are imbeded.

3. Whether the remains of marine and terreſtrial animals are found intermixed in the ſame *ſtratum*.

4. Whether a bed of foſſil ſhells conſiſt of one ſelect ſpecies, or more than one; and whether the bivalves are united and appear whole, or only as the fragments of ſhells.

5. To obſerve whether ſuch *exuviæ* are natives of the climate where found, or of diſtant regions of the earth.

Such are the appearances upon which the preſent inquiry depends: therefore in order to obtain the ſeveral ends propoſed, it becomes neceſſary to recite the obſervations of ſome eminent naturaliſts on foſſil ſhells and other animal *exuviæ*, as well as thoſe which have occurred in the courſe of my own inſpection, in various parts of England.

But

But previous thereto, let us ſuppoſe for the preſent that marine animals were created prior to the primitive iſlands, or while the ſea prevailed univerſally over the earth; in order to conſider the conſequences thence ariſing, with reſpect to the *exuviæ* of marine animals.

The generality of marine animals being naturally prolific, and having an unlimited field for their ſupport; they might probably increaſe and multiply ſo exceedingly in a ſhort ſpace of time, as to repleniſh the ocean from pole to pole.

And if the ocean were thus plentifully ſtocked with inhabitants previous to the appearance of dry land, it may be preſumed, that many of theſe animals became daily enveloped and buried in the mud, by the daily action of the tides; according to Chap. VI.

Hence it appears, that the deeper the primitive ocean, the greater ſpace of time elapſed before the iſlands were formed; and the deeper theſe marine bodies were entombed.

And, as the different ſpecies of marine animals are endued with different degrees of activity, thoſe particular ſpecies which were the leaſt active, would conſequently be the leaſt able to defend, or extricate themſelves from ſuch interments.

Therefore ſince all ſpecies of ſhell fiſh are much leſs active than the finny kinds, the former were probably thus entombed in much greater numbers than the latter.

Such we preſume would have been the conſequences neceſſarily ariſing from the creation of marine animals, prior to the appearance of dry land: and therefore when it is conſidered, that according to Chap. V. the ſea prevailed univerſally over the earth; it ſeems highly probable that theſe marine inhabitants were enveloped and buried in the mud in all parts of the ſea, from pole to pole.

And if they were thus buried and deprived of life, in ſucceſſive periods of time, they muſt neceſſarily be found in different ſtates of decay, and their native teſtaceous matter become more or leſs changed to the ſubſtance of the *ſtrata* wherein they are included.

Having proceeded thus far hypothetically, by ſuppoſing that marine animals were created prior to the primitive iſlands; it remains now to inquire into the various phenomena relative to the *exuviæ* of marine animals, and thence to conclude whether the preceding conjectures are true or fallacious.

According to the concurring teſtimony of many eminent naturaliſts, foſſil ſhells and other marine relics, have been obſerved in all parts of the world hitherto explored; even upon the higheſt mountains and in parts remote from the ſea; likewiſe in vallies and deep receſſes of the earth, imbeded in the ſolid ſubſtance of limeſtone, chalk, clay, and gravel. But that in every inſtance we have hitherto obſerved, the fragments of ſea ſhells are infinitely more numerous than the bones and teeth of fiſh. The latter too are but rarely depoſited in any other matter than in beds of ſand and gravel; and not in the ſolid ſubſtance of limeſtone, as the ſhells of fiſh generally are, even to the depth of many hundred yards, and diſperſed throughout the whole extent of the *ſtrata*: of which the cliffs and caverns in Derbyſhire, Staffordſhire, and almoſt every other country productive of limeſtone, exhibit innumerable inſtances: but of this more hereafter.

The obſervations of Count Buffon, the celebrated naturaliſt, on the ſubject of foſſil ſhells and other marine *exuviæ*, contain many valuable and intereſting facts. He ſays,

"1. Foſſil ſhells are found on the Alps, on the top "of mount Cenis, on the Apennines, on the mountains "of Genoa, and in moſt of the quarries of ſtone and "marble in Italy; in moſt parts of Germany and Hungary, and indeed generally in all the elevated places in "Europe. We alſo find them in the ſtones whereof the "moſt ancient edifices of the Romans were conſtructed.

"2. In Switzerland, Aſia, and Africa, travellers have "obſerved petrified fiſh, in many places: for inſtance, "on the mountains of Caſtravan, there is a bed of white "laminated ſtone, and each *lamina* contains a great number

" ber and diverſity of fiſhes; they are, for the moſt " part very flat, and extremely compreſſed, in the manner of foſſil fern; yet they are ſo well preſerved, that " the minuteſt marks of their fins and ſcales are diſtinguiſhable, and every other part, whereby one ſpecies " of fiſh is known from another.

" 3. There are likewiſe many *echinites* and petrified " fiſh between Iver and Cairo, and on all the hills and " heights of Barbary, moſt of which exactly correſpond " with the like ſpecies taken in the Red Sea.

" 4. The long chain of mountains, which extend " from eaſt to weſt, from the lower part of Portugal " quite to the moſt eaſtern parts of China, thoſe which " ſtretch collaterally to the north and ſouth of them, " together with the mountains of Africa and America, " which are now known to us, all contain *ſtrata* of " earth and ſtone, full of ſhells.

" 5. The iſlands of Europe, Aſia, and America, " wherein Europeans have had occaſion to dig, whether " in mountains or plains, all furniſh us with ſhells, and " convince us that they have this particular in common " with their adjacent continents.

" 6. The *gloſſopetra*, or the teeth of ſharks, and of " other fiſhes, are found in the jaws, poliſhed and worn " ſmooth at the extremities; conſequently muſt have " been made uſe of during the life of the animal; and

" in the ſhells, the very pearls are found, which the
" living animals of the ſame kind produce.

" 7. It is well known that the *purpura* and *pholades*
" have a long pointed proboſcis, which ſerves them as a
" kind of gimblet or drill, to pierce the ſhells of living
" fiſh, on whoſe fleſh they feed. Now ſhells thus
" pierced are found in the earth, which is another in-
" conteſtible proof that they heretofore incloſed living
" fiſh, and that theſe fiſh inhabited places where the
" *purpura* and *pholades* preyed on them.

" 8. In Holland, ſea ſhells are found a hundred feet
" below the ſurface; at Merly-la-Ville, ſix leagues from
" Paris, at ſeventy-five; and in the Alps and Pyrenean
" mountains they are found under beds of ſtone of a
" hundred, nay even a thouſand feet.

" 9. Shells are likewiſe found in the mountains of
" Spain, France, and England; in all the marble quar-
" ries in Flanders; in the mountains of Guilders; in all
" the hills round Paris; in thoſe of Burgundy and
" Champagne; and, in ſhort, in all places where the
" baſis of the ſoil is neither *freeſtone* nor *ſandſtone*.

" 10. By ſhells I would be underſtood to mean, not
" only thoſe which are merely teſtaceous, but the relics
" of the cruſtaceous fiſhes alſo; and even all other ma-
" rine productions: and I can venture to aſſert, that in
" the generality of marbles there is ſo great a quantity of

“ marine productions, that they appear to ſurpaſs in
“ bulk the matter whereby they are united.

“ 11. Among the many inſtances of the multiplicity
“ of oyſters, there are few more extraordinary than that
“ immenſe bed which M. de Reaumur gives an account
“ of, which contains 130,630,000 cubic fathoms.
“ This vaſt maſs of marine bodies is in Touraine in
“ France, at upward of thirty-ſix leagues from the ſea.
“ Some of theſe ſhells are found ſo intire, that their
“ different ſpecies are very diſtinguiſhable.

“ 12. Some of the ſame ſpecies are found recent on
“ the coaſt of Poictou, and others are known to be na-
“ tives of more diſtant parts of the world. Among
“ them are likewiſe blended ſome fragments of the more
“ ſtony kinds of ſea plants, ſuch as *madripores*, *fungi*
“ *marini*, *&c.* The canton of Touraine contains full
“ nine ſquare leagues in ſurface, and furniſhes theſe
“ fragments of ſhells, wherever you dig.” Thus far
M. Buffon. See his Natural Hiſtory.

We ſhall, however, be leſs aſtoniſhed at this very conſiderable quantity of ſhells, when we conſider the vaſt increaſe of ſhell fiſh. It is not uncommon to take away a bed of theſe ſhell fiſh, ſeveral fathoms in thickneſs; and though the places where they are fiſhed for appear to be intirely exhauſted, yet, in the enſuing year, there ſhall be as many found in all theſe places as before: nor do I remember to have heard that any place whence they were taken, had ever been intirely exhauſted.

" 13. Near Reading in Berkſhire, a continued body " of oyſter ſhells has been found; they lie in a *ſtratum* " of greeniſh ſand, about two feet in thickneſs, and ex-" tend over five or ſix acres of ground; they are covered " by *ſtrata* of ſand and clay, upward of fourteen feet " deep: ſeveral whole oyſters are found with both their " valves or ſhells lying together, as oyſters before they " are opened; the ſhells are very brittle, and in digging " them up, one of the valves will frequently drop from " its fellow. Several are dug out intire; nay ſome " double oyſters, with their valves united." And,

" 14. In a quarry at the eaſt end of Broughton in " Lincolnſhire, innumerable fragments of the ſhells of " ſhell fiſh, of various ſorts, are found under a *ſtratum* " of ſtone embodied in clay, with pieces of coral, and " ſometimes whole ſhell fiſh, with their natural ſhells " and colours; ſome are moſt miſerably cracked, bruiſed " and broken; others totally ſqueezed flat by the in-" cumbent weight of earth." Lowthorp's Abridg. Phil. Tranſ. vol. ii. p. 428.

" 15. Sharks teeth are dug up in the iſle of Sheppey, " retaining their natural colour not petrified.

" 16.

16. " The teeth of ſharks, have likewiſe been taken " out of a rock in Hinderſkelf Park, near Malton in " Yorkſhire." Ibid. p. 430.

17. " In the iſle of Caldey, and elſewhere about " Tenby in Pembrokeſhire, marine foſſils have been " found in ſolid marble, on the face of the broken ſea " cliffs, *two hundred fathoms* below the *upper ſurface* " *of the rocks*. Nor were they only obſerved upon the " face of theſe rocks, but even more or leſs throughout " the whole maſs or extent of them. This is manifeſt " from divers rocks hewn down by workmen for making " of lime, and other pieces caſually fallen from the " cliffs." And,

18. " Thouſands of foſſil teeth, exactly anſwering " to thoſe of divers ſorts of ſea fiſh, have been found in " quarries and gravel pits about Oxford." Ray, 3 Diſ. p. 178. 182.

19. " At Thame in Oxfordſhire, the *belemnites*, or " thunderbolt ſtones, are found in a *ſtratum* of blue clay, " which ſtill retain their native ſhelly ſubſtance.

20. " The *belemnites* found in gravel pits, have ſuf" fered much, by their being rubbed againſt each other " in the fluctuation of waters.

21. " The *nautili* and *belemnites* are frequently found " at Garſing near Oxford." Philoſophical Tranſactions, vol. liv. p. 5.

22. " At Weſtbere, an obſcure village, about three " miles eaſt of Canterbury, many oyſters and other ſhells " were dug up, at a conſiderable depth, together with " an *iron anchor :* and another anchor was dug at Broom " Down, on the ſame ſide the level.

23. " Hardel Cliff, in Hampſhire, contains a great " variety of turbinated and bivalve ſhells, which ſtill " retain the native matter and colour of marine ſhells ; " many of theſe are natives of very diſtant regions, and " others of them are not known to exiſt in a living ſtate.

24. " In ſome parts of Suffolk, I am told, foſſil ſhells " are ſo numerous, that they are dug up for manure, and " produce excellent crops. Theſe ſhells retain much " of their native marine matter ; they are much decayed " and blunted, as ſhells by rolling on the ſea coaſt.

25. " Sheppey Iſle, and other parts of Kent, abound " with foſſil ſhells, which ſtill retain their native colour " and conſiſtence ; likewiſe the teeth and *vertebræ* of " fiſh, and, in particnlar thoſe of the ſhark ; alſo the re- " mains of cruſtaceous fiſhes, as crabs, lobſters, &c.

26. " In a hill called Catſgrove, in Berkſhire, a great " number of oyſters are dug up intire, but crumble in- " to duſt, when expoſed to the air. In the ſame place " are alſo found periwinkle ſhells, whoſe ſpirals are re- " verſed to thoſe in the adjacent ſea.

27. "Rungwell Hill, in Surry, is ſaid to contain "oyſter ſhells not petrified, nor much decayed, and ſo "like to oyſters newly taken from the ſea, that they "have been opened for ſuch, in expectation of finding "living fiſh therein." Ray, 3 Diſ. p. 129.

28. Near Stableford, the ſeat of the Earl of Harborough, ſeveral beds of ſea ſhells were lately diſcovered, incloſed in calcarious earth; theſe ſhells ſtill retain their native marine matter, though much decayed. The limeſtone *ſtrata* in that neighbourhood abound with different ſpecies of foſſil ſhells, in a petrified ſtate.

29. Many parts of Northamptonſhire contain foſſil ſhells, in great abundance, in part and wholly petrified, and, in particular, a ſpecies of oyſter, ſaid to be a native of the Mediterranean Sea. I have in my poſſeſſion a fragment of a *Cornu-Ammonis*, dug up near Northampton, which retains its native ſhell.

30. In Sir Aſhton Lever's excellent Muſeum, there are ſeveral curious ſpecimens of the *Cornu-Ammonis*, with their native ſhelly matter remaining: ſuch inſtances are rare, and of great value, by pointing out the origin of them.

31. "In ſome parts of Virginia, for ſeveral miles together, the ſoil is ſo intermixed with oyſter ſhells, that "there ſeems to be as great a quantity of ſhells as of "earth: how deep they lie thus intermixed, I think, "is not yet known; for in the broken banks they are

“ continued many yards perpendicular. In ſeveral places “ the ſhells are much cloſer, and being petrified, ſeem “ to form a *ſtratum* of ſtone. I have ſeen, in ſeveral “ places, veins of theſe rocky ſhells, three or four yards “ thick, at the foot of a hill, whoſe perpendicular “ height might be twenty or thirty yards. Of theſe rocks “ of oyſter ſhells that are not ſo much petrified, they “ burn and make all their lime.

32. “ Often in the looſer banks of ſhells and earth, “ are found perfect teeth petrified, ſome of them not leſs “ than two or three inches long, and above one inch “ broad; the part that one might ſuppoſe to grow out “ of the jaw was poliſhed, and black almoſt as jet, the “ other brown, and not ſo ſmooth.

33. “ The back-bone of a whale, and ſeveral ribs, “ were dug up out of the ſide of a hill ſeveral yards deep, “ about four miles diſtant from James-Town and the “ river. Another back-bone of a whale, and ſeveral “ teeth, were found in hills beyond the falls of James- “ River, at leaſt one hundred and fifty miles up the “ country.” Lowthorp's Abridg. Philoſ. Tranſ. vol. iii. p. 581.

34. “ Foſſil bones and ſhells of ſeveral ſorts, have “ been found in Maryland; ſome of them have received “ little alteration in the earth, others more, and ſome “ were ſo changed as to be ſtony; but all of them re-

" tained their ancient ſhape. Some of them were com-" pared to the tongue and palate of a fiſh obſerved at " Jamaica, and found perfectly analogous to each other." Lowthorp's Abridg. Phil. Tranſ. vol. ii. p. 431.

35. " Naphat, a remarkable mountain in Ireland, ſaid " to be elevated ſeveral hundred fathoms above the level " of the ſea; yet, within ten yards of the top of this " mountain, there are ſeveral vaſt beds of marine ſhells " of various kinds: as whelks, muſcles, cockles, &c. " and parallel to theſe are thoſe vaſt mountains in Virgi-" nia, and other parts of America."

36. In the mountainous tracts of Derbyſhire, and in the moorlands of Staffordſhire, I have frequently obſerved with aſtoniſhment enormous maſſes of limeſtone compoſed almoſt intirely of foſſil ſhells or other marine relics; diffuſed throughout the ſolid ſubſtance of the *ſtrata:* And it is likewiſe obſervable that, in many inſtances, theſe maſſes of ſtone will ſometimes abound with one ſelect ſpecies, of cockles, *entrochi*, corralines, &c.

37. And others of them with a variety of ſpecies confuſedly blended together.

The former inſtance is notorious in the Derbyſhire marble, wherein the *entrochi* are alone conſpicuous. And wherever the bivalve ſpecies are obſerved with both their valves intire, and cloſe as the ſhells of living fiſh, they likewiſe form ſelect claſſes.

38. But in every inſtance wherein the beds of ſhells conſiſt of ſeveral ſpecies blended together, the valves are not united, but ſeparate from each other, as the fragments of ſhell fiſh when aſſembled together in the ſea, by the fluctuation thereof.

39. I have likewiſe obſerved in a *ſtratum* of ſhale, or indurated clay, at Claxby in Lincolnſhire, great numbers of foſſil ſhells, which perfectly retain the native colour, figure, and conſiſtence of marine ſhells. The ſame *ſtratum* likewiſe contains nodules of ironſtone, which are generally accompanied with vitriolic acid, and which ſeems to have operated in ſome degree upon the exterior part of the ſhells, ſo as to diveſt them of their external brown cruſt, and to exhibit that of a pearly colour only. This *ſtratum* of ſhale was perforated ſeventy yards deep in ſearch for coal, and ſuch remains as above deſcribed were formed to that extraordinary depth; how much deeper the ſhale and the ſhells might continue, has not hitherto been aſcertained. Though the ſhells are apparently in high preſervation, the ſhale is covered by an incumbent *ſtratum* of limeſtone, fifteen or twenty yards thick.

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40. I may add to the above that I have alſo obſerved ſomewhat ſimilar phenomena in very many other parts of England, but they are ſo extremely notorious that it is altogether needleſs to relate any more ſuch inſtances.

41. Though foſſil ſhells are ſo extremely numerous in every part of the world, yet, ſo far as my obſervations have extended, the bones and teeth of fiſh are never intermixed therewith in the ſolid ſubſtance of limeſtone, and rarely under any other circumſtances, but with adventitious bodies.

42. In the iſle of Sheppey, the teeth of ſharks, and the bones of fiſh are frequently gathered at the foot of the mouldering cliffs, not petrified, but much tarniſhed as it were with pyrites, or vitriolic acid, which vaniſhes by the operations of air, or weather. The above cliffs are compoſed of argillaceous earth, and contain a variety of extraneous bodies, inſomuch that the whole of the iſland ſeems to be an aſſemblage of adventitious matter. I have found therein ſeveral pieces of petrified wood, which have been apparently wrought, and have been originally much perforated by ſea worms. And this idea, is abundantly corroborated by the timber lately found at Sheerneſs three hundred feet deep, by ſinking a well for the purpoſe of obtaining freſh water.

43. The iſle of Sheppey contains a great variety of foſſil bodies belonging to the animal and vegetable kingdoms, which evidently ſhew it to be an aſſemblage of adventitious matter.

The remains of marine animals imbeded in the ſolid ſubſtance of ſtone, chalk, and clay, and in ſand, gravel, &c. in all parts of the known world, are ſo extremely numerous, that it ſeems altogether needleſs to add any more inſtances relative to their origin: let us therefore proceed to a recapitulation of the ſeveral facts, in order to draw ſome general concluſions concerning them.

1. Foſſil bodies reſembling, both in ſubſtance and ſhape, the ſhells of living fiſh, are found imbeded upon the higheſt mountains, in vallies, and in deep receſſes of the earth, remote from the ſea.

2. They are found retaining the native teſtaceous matter, colour, and figure of marine ſhells; inſomuch as not to have been diſtinguieſhd from the ſhells of living fiſh, and have even been opened for ſuch, in expectation of finding living fiſh therein.

3. Foſſil ſhells are alſo found in various ſtates of decay, and variouſly impregnated with ſtony or metallic matter, and even wholly changed to the ſubſtance of the ſtone in which they are imbeded.

4. They are found in the ſolid ſubſtance of the limeſtone *ſtrata*, diſperſed throughout their whole extent and thickneſs, though ſome of them are not leſs than 150 or 180 feet thick; of which ſee Chap. XVIII. They are alſo involved in *ſtrata* of chalk and clay.

5. The bivalve ſpecies are ſometimes found with both their ſhells intire and cloſe, as thoſe of living fiſh: and when thus found, each bed conſiſts of one particular ſpecies:

cies; namely, oyſters, cockles, muſcles, &c. ſelected together, as the ſame ſpecies are actually aſſembled together in the ſea.

6. But on the contrary, when beds of foſſil ſhells are compoſed of fragments or ſeparate bivalves, they conſiſt of a great variety of ſpecies confuſedly blended together, in like manner as the fragments of ſea ſhells are thrown together by the fluctuation of the ocean.

7. Foſſil bones and teeth, reſembling thoſe of fiſh, are alſo found retaining the perfect colour, figure, and poliſh of recent teeth, and even apparently worn by uſe: but though the number of ſuch foſſil bodies are very conſiderable, yet thoſe reſembling the ſhells of fiſh are infinitely the more numerous: and I have not been able to diſcover from my own obſervations, a ſingle inſtance of the former being imbeded with the latter, in the ſolid ſubſtance of the limeſtone *ſtrata* in Derbyſhire, or elſewhere; but conſtantly with a variety of adventitious matter near the ſurface of the earth.

8. And we may add to the above, that the remains of terreſtrial animals are ſeldom or never found intermixed with marine relics, in the limeſtone *ſtrata*; neither are thoſe of the ſea ever found, or but rarely, in the argillaceous *ſtrata* containing the impreſſions of vegetables.

Such are the general phenomena attending the above foſſil bodies; whence the following inferences ſeem to ariſe.

Firſt, Their great analogy in figure, colour, and conſiſtence, to the ſhells, bones, and teeth of living fiſh, together with a gradual change in their component parts, from a teſtaceous, to a ſtony, or metallic ſubſtance, evidently ſhew that all ſuch foſſil bodies were originally productions of the ſea.

Secondly, Their being found in all parts of the world, even imbeded in the higheſt mountains, vallies, and deep receſſes of the earth, remote from the ſea, evidently ſhews that the ſea prevailed univerſally over the earth, according to Chap. V. and conſequently, that theſe marine animals were created prior to the primitive iſlands, and likewiſe prior to terreſtrial animals, agreeable to the ſcripture account of the creation.

Thirdly, And ſince they are found at various depths in the earth, even to that of ſeveral thouſand feet, and in different ſtates of decay, and variouſly impregnated with ſtony or metallic matter, and even changed to the ſubſtance of the ſtone in which they are imbeded; it evidently appears, that the *ſtrata* were originally in a ſtate of fluidity, and that they were thus entombed and deprived of life in ſucceſſive periods of time, according to the preceding conjectures, page 40.

Fourthly, The beds of foſſil ſhells which conſiſt of one ſpecies only, and are not natives of the climate where found, but of very diſtant regions of the earth, evidently ſhew, that they were generated, and have lived and died, in the very beds where found, and could not have been removed from their native climates by a flood, or floods of water with ſo much order, as to form beds conſiſting of only one ſelect ſpecies; and therefore all ſuch beds muſt have been originally the bottom of the ocean.

Such are the inferences deduced from the preceding facts; which tend to corroborate the ſeveral reſults ariſing from the former parts of this inquiry, into the original ſtate and formation of the earth: namely, that the earth was originally a fluid chaotic maſs, totally unfit for animal or vegetable life.—That it was progreſſively formed into a habitable world.—That marine animals were created prior to the primitive iſlands, and conſequently prior to terreſtrial animals.—That they were entombed in the bowels of the earth, in ſucceſſive periods of time, and before dry land appeared.

I ſay this agreement of facts with the laws and operations of nature, and alſo with the Moſaic account of the creation, leave little room to doubt, but that the inferences contained in the preceding pages, have ſome foundation in nature and truth: therefore, notwithſtanding any errors I may have committed in the arrangement of the facts, or in the inferences thence deduced; yet, I flatter myſelf, that the ſubject matter thereof will ſometime or other be rendered equally as permanent and ſatisfactory to a rational mind, as any mathematical demonſtration whatever.

CHAP. VIII.

General Obſervations on the ſuperficial and interior Parts of the Earth.

NOtwithſtanding the concluſions we have drawn in the preceding chapter, have ſo much the appearance of truth, nevertheleſs, ſome objections may poſſibly ariſe in the minds of thoſe readers, who have been accuſtomed to conſider *mountains* and *continents* as *primary* productions of nature. Such readers I preſume may probably reaſon thus with themſelves:

"If the foſſil ſhells which are found imbeded in the "tops of the higheſt mountains were actually generated, "and have lived and died, in the very beds wherein they "are found, thoſe beds muſt have been originally the "bottom of the ocean; and if ſo, pray, whence pro- "ceed all theſe vaſt alterations on the ſuperficial parts

“ of the earth? Why hath the ſea deſcended ſo far beneath thoſe mighty eminences, the *Alps*, the *Andes*, the *Pyreneans*, &c. and why hath it retired from thoſe extenſive tracts of land, the *continents?* Where not theſe things originally thus created? If not, pray whence proceed theſe great inequalities? Hiſtory is ſilent concerning ſuch events; and tradition is too faint to reſt much proof upon it; therefore, ſince we have no written evidence to help us in the ſcrutiny, and tradition itſelf fails us through age, we cannot wholly aſſent to the preceding concluſions, until theſe apparent objections are removed.”

To ſuch candid inquirers I beg leave to anſwer, that whoever attentively views and conſiders the preſent ſtate and condition of the terraqueous globe; its craggy rocks and mountains, its ſteep, angular, and impending ſhores, ſubterraneous caverns, &c. will be almoſt perſuaded, without any farther inquiry, that theſe romantic appearances are not the effects of a regular uniform law, but of ſome tremendous convulſions, which have thus burſt its *ſtrata*, and thrown their fragments into all this confuſion and diſorder: nay, the very repreſentation of ſea and land, upon a geographical chart, ſeems alone ſufficient to eſtabliſh the truth of ſuch a conjecture.

Let us not, however, take thoſe things for granted which we are able to inveſtigate from a ſeries of undeniable facts: it is one thing to aſſert a truth, and another to prove it; the former leaves the mind in a ſtate of ſuſpence, the latter in poſſeſſion of *truth*.

But before we attempt to inveſtigate the cauſe of theſe wonderful appearances, let us endeavour to recollect the general ſtate and condition of them.

We are told that “ Norway abounds with ſtupendous “ rocks and mountains, as it were cloven aſunder, or “ cut with ſaws, both acroſs and lengthwiſe. Some of “ them are remarkable for their appearances; on the “ left hand, ſailing up Joering Creek, there appears ſuch “ a group of the creſts of mountains, as reſemble the “ proſpect of an old city, with towers and Gothic edifices: ſome of them are continually covered with “ ſnow, while the chaſms in others make way for the “ light to penetrate.

The ſea ſhore too, is almoſt every where ſteep, angular and impending, inſomuch that the water, cloſe “ to the rocks, is generally three ot four hundred fathoms deep; and in Floge Creek no bottom can be “ found with a line of one thouſand fathoms.

“ Nordall Creek is alſo ſaid to be nine hundred fathoms deep: and other creeks which run thirty miles “ up the country, are alſo ſaid to be three or four hundred fathoms deep, and the bottom of the ſea and “ other waters in that country conſiſt of rocks, moun-

"tains, and vallies, like the land." Thus far Biſhop Pontoppidon's Hiſtory of Norway.

We are alſo told, that many other parts of the world are in a ſimilar ſtate to thoſe of Norway.

The mountains in Derbyſhire, and the moorlands of Staffordſhire, appear to be ſo many heaps of ruins, and more eſpecially the latter; for, in the neighbourhood of Ecton, Wetton, Dovedale, Ilam, and Swithamly, the *ſtrata* lie in the utmoſt confuſion and diſorder. They are broken, diſlocated, and thrown into every poſſible direction, and their interior parts are no leſs rude and romantic; for they univerſally abound with ſubterraneous caverns; and, in ſhort, with every poſſible mark of violence. The caverns near Buxton and Caſtleton, and the ſubterraneous rivers, the Manifold and the Hamps, are familiar inſtances of the preſent ſtate and condition of thoſe parts of the globe. The former river, after a paſſage of four or five miles from the north, and the latter about the ſame diſtance from the weſt, both emerge at the foot of the ſame cliff, in the garden of John Port, Eſq. of Ilam, about the diſtance of twenty yards from each other.

We may add, to the above phenomena, thoſe large blocks of ſtone which are ſcattered over the ſurface of the earth, in mountainous countries, and mingled with their reſpective ſoils to very conſiderable depths, as if they had been originally ejected from their native beds by ſubterraneous blaſts, as ſtones are frequently ejected from Veſuvius, Etna, or any other ſuch powerful agents.

The above fragments are attended with the following ſingular circumſtances. Thoſe which lie near their native beds are too numerous and maſſy for the hand of man to have placed them there, and they lie in as much diſorder as ſtones caſually thrown together. The banks on the eaſt ſide of the river Derwent, from Crich Cliff, twenty miles up the river, are thus covered; and the ſame phenomena may be obſerved on the ſides of many other mountains in Derbyſhire and Staffordſhire.

As theſe ſtones lie ſo near their original *ſtratum*, we may eaſily ſatisfy ourſelves that they are detached parts thereof; and, by analogy, the more diſtant fragments may be aſcertained with equal certainty, though at the diſtance of ten or twenty miles.

In the neighbourhood of Utoxeter, in Staffordſhire, blocks of limeſtone are frequently dug up four or five hundred weight each; and yet I cannot learn that there are any quarries of the ſame kind of ſtone nearer than four or five miles.

Fragments of ſtone perfectly analogous to the former, were dug up at Etwall in Derbyſhire. A well being ſunk to the depth of eleven yards, many of theſe ſtones were found intermixed with other adventitious bodies, from the ſurface of the earth to that depth, ſome of them were ſix or eight pounds weight, and ſome ſmaller. Now although Etwall cannot be leſs than fifteen or twenty miles from any known quarry of the ſame kind, we cannot help concluding that they were originally ejected to that diſtance; ſince ſuch effects are frequently produced by ſubterraneous exploſions: and what makes this conjecture more probable is, the ſame phenomena have been obſerved in other wells in that village.

I have frequently obſerved in the neighbourhood of Stafford, and Newport in Shropſhire, detached blocks of Corniſh moorſtone, or granite, of conſiderable magnitudes, though no ſuch *ſtratum* is known to exiſt nearer than Cornwall.—And ſuch extraneous ſubſtances are not peculiar to Derbyſhire, Staffordſhire, and Shropſhire, for they abound in many other parts of England; and particularly in the county of Cheſter, in which the fragments of blue quartzore ſtone ſeems to be univerſally intermixed with its ſoil; for wherever pits or wells are dug to obtain water, or its rivers waſh down their adjacent banks, ſuch ſtones are uſually found.

The generality of theſe fragments are rounded, as it were by attrition, as ſtones upon a ſea beech; and are uſually applied to the paving of ſtreets, public roads, &c. Some of theſe detached blocks are not leſs than fifteen or twenty hundred weight each. I have obſerved a *ſtra-*

tum ſimilar to the above, in the north part of Wales, and upon the Reken in Shropſhire. But there is not the leaſt appearance of ſuch a *ſtratum* in Cheſhire, the ſoil of which is in general compoſed of adventitious matter, apparently aſſembled together by the fluctuation of water; of which we ſhall give ſome notorious inſtances in the future part of our work.

The phenomena above recited may be conſidered as ſo many inſtances of the great alterations which the earth has undergone by ſubterraneous convulſions.

But theſe ſuppoſed events, or great revolutions, having happened anterior to hiſtory, render ſome inquiry into the effects recently produced by ſubterraneous convulſions neceſſary, in order to compare the appearances of the former with the effects of the latter; and this, as the only means of obtaining a permanent idea of the real cauſe of ſuch phenomena.

But the ſubject of this inquiry we reſerve for the enſuing chapter.

CHAP.

CHAP. IX.

Of the Alterations produced on the ſuperficial Parts of the Earth, ſince the Commencement of Hiſtory, by Means of ſubterraneous Convulſions.

WE learn from Pliny, and many other natural hiſtorians, that the ſuperficial parts of the earth have ſuffered conſiderable alterations and changes at ſundry periods of time, viz.

Firſt, That many mountains have been raiſed, and others depreſſed, or totally ſwallowed up into the bowels of the earth, together with cities and large diſtricts of land; and that navigable lakes have appeared in the places thereof.

Secondly, That many mountains have been ſhivered to pieces, and the fragments thereof thrown into the adjacent vallies, and in ſome inſtances even to the diſtance of ten, twenty, or thirty miles.

Thirdly, That great cliffs or fiſſures have been burſt open, and that rivers of boiling water and melted matter have flowed from thence, and deluged the adjacent countries with liquid fire, or water; and likewiſe, that great agitations of the ſea, and alſo of lakes and rivers, have frequently accompanied thoſe tremendous convulſions of nature: and in ſome inſtances the ſea has overflowed its natural bounds, and deluged the adjacent country, and even conveyed ſhips of conſiderable burden many miles into the interior parts thereof.

Such have been the notorious effects ariſing from ſubterraneous convulſions in all preceding ages, from the firſt commencement of hiſtory down to the preſent era: and therefore both the interior and exterior parts of the earth have ſuffered conſiderable alterations and changes compared with its primitive ſmoothneſs and regularity, according to the reſult of Chap VI.; as the following inſtances will evidently ſhew.

But let us firſt recite a few recent marks of violence, in order to ſtrengthen the credibility of thoſe which are ſaid to have happened in the more early ages of the world.

1. We are told, that during the dreadful earthquake, which deſtroyed Liſbon, on the firſt of November 1755, "the mountains of Arrabida, Eſtretta, Julio, Marvan, "and Cintra, being ſome of the largeſt in Portugal, "were impetuouſly ſhaken, as it were to their very foun-"dations; and ſome of them opened at their ſummits, "ſplit, and rent in a wonderful manner, and huge "maſſes of them were thrown down into the adjacent "vallies." Hiſt. and Phil. of Earthquakes, p. 317.

2. " A fine

2. “A fine new ſtone quay in Liſbon, where the “merchants landed their goods, where at that time “about three thouſand people were aſſembled for ſafety, “was turned bottom upward, and every one loſt; nor “did ſo much as a ſingle body appear afterward.” Phil. Tranſ. vol. xlix. p. 412.

3. “A ſea port, called St. Ubals, was intirely ſwal-“lowed up, people and all.” Ibid, p. 413.

4. “About eight leagues from Morocco, the earth “opened, and ſwallowed up a village, with all its inhabi-“tants (who were known by the name of the ſons of “Buſunba) to the number of eight or ten thouſand “perſons, together with their cattle of all ſorts, as ca-“mels, horſes, horned cattle, &c. and ſoon after the “earth cloſed again, in the ſame manner it was be-“fore.” And,

5. “One of the Sarjon Hills was rent in two; one “ſide of which fell upon a large town, where there was “the famous ſanctuary of their prophet, known by the “name of Mula Teris; and the other ſide of the ſaid “hill fell down upon another large town, and both “towns and inhabitants were all buried under the ſaid “hill.” Ibid, p. 431.

6. “The famous city Taſſo was wholly ſwallowed “up; no remains being left.” Phil. Tranſ. vol. xlix. p. 432.

We have likewiſe many other authentic accounts of this fatal and extenſive earthquake, in the periodical papers.

7. "The grand city of Mequinez is no more, it was " buried in the bowels of the earth, on the nineteenth " of November (1755) by a violent ſhock of an earth- " quake, which likewiſe ſwallowed up, at ſeveral " leagues diſtance, two camps of moving Arabs, up- " ward of four hundred tents, containing twenty-five or " thirty perſons each, with a large tract of country." Univerſal Mag. vol. xvii. p. 282.

8. "At Mequinez, that part of the city where the " Jews reſided, was intirely ſwallowed up, and all the " people of that ſect (about four thouſand in number) " periſhed, except ſeven or eight." Ibid, vol. xviii. p. 28.

9. "In the year 1692, a great part of Port-Royal " in Jamaica was ſunk by an earthquake, and remains " covered by water ſeveral fathoms deep; ſome chimnies " and maſts of ſhips excepted, which appear above water. " On the north ſide, above 1000 acres of land ſunk. Some " mountains along the river, between Spaniſh-Town and " Sixteen-mile Walk, were joined together; and others " ſo thrown on heaps, that people were forced to go by " Guanaboa to Sixteen-mile Walk. At Yellows, a " great mountain ſplit, and fell into the level land, and " covered ſeveral ſettlements. Another plantation was

" removed half a mile from the place where it formerly " ſtood. In Clarendon precinct the earth gaped prodigiouſly; and all over the iſland there were abundance " of openings; nay, many thouſands; but in the " mountains are ſaid to have been the moſt violent " ſhakes: indeed they are ſtrangely torn and rent, inſomuch that they ſeem to be of different ſhapes now, " from what they were, eſpecially the Blue and other " higheſt mountains, which ſeem to have been the greateſt ſufferers. And a large high mountain near Portmorant, near a day's journey over, is ſaid to be quite " ſwallowed up; and in the place where it ſtood there is " now a great lake, of four or five leagues over. The " Blue and its neighbouring mountains uſed to afford a " fine green proſpect; now one half part of them at " leaſt ſeem to be wholly deprived of their natural verdure. " There one may ſee where the tops of great mountains " have fallen, ſweeping down all the trees, and every " thing in their way, and making a path quite from top to " bottom." Lowthorp's Abr. Phil. Tranſ. vol. ii. p. 417.

10. " In the year 1699, ſeven hills were ſunk by an " earthquake, in the iſland of Java, near the head of " the great Batavian river, five on this ſide and two on " the other. And nine more were likewiſe ſunk on this " ſide the Tangarang river. Between the Batavian and " Tangarang rivers, the land was rent and divided aſun-

"der, with great clefts, more than a foot wide." Lowthorp's Abridg. Phil. Tranſ. vol. ii. p. 419.

11. "In the year 1538, the famous town called St. "Euphemia, ſituate at the ſide of the bay, under the "juriſdiction of the Knights of Malta, was totally ſwal-"lowed up, with all its inhabitants, and nothing ap-"peared but a ſtinking lake in the place of it." Dr. Hooke's Poſt. p. 306.

12. "The Pico, in the Moluccos, accounted of equal "height with that of Teneriffe, was ſunk by an earth-"quake, and quite ſwallowed up into the earth, and "left a lake in its place." And,

13. "In the year 1646, many of thoſe vaſt moun-"tains of the Andes were quite ſwallowed up and loſt." Ibid, p. 307.

14. "The 11th of January, 1693, a mighty earth-"quake happened in Sicily, and chiefly about Catanea: "the violent dancing of the earth threatened the whole "iſland with intire deſolation. The earth opened in "ſeveral places, in very long clefts, ſome a hand's "breadth, others half a palm, others like great gulphs. "In the plain of Catanea, water was thrown from thoſe "long clefts, altogether as ſalt as the ſea. Great rocks "were thrown down every where, and in the country "of Lotino, a great number of people periſhed in the "houſes beaten down by the rocks rolling down the hills.

" A great number of noble ſtructures lie, like a horrid " deſert, in vaſt heaps of ruins, and not leſs than " 59,969 perſons were deſtroyed by the fall of them, in " the different parts of Sicily." Lowthorp's Abridg. Phil. Tranſ. vol. ii. p. 408, 409.

Having enumerated a few recent inſtances of the alterations produced on the ſuperficial parts of the earth, by ſubterraneous convulſions, we may venture to recite thoſe which happened in the more early ages of the world.

Pliny has not only recorded many extraordinary phenomena which happened in his own time, but has likewiſe borrowed many others from the learning of more ancient nations.

15. " A city of the Lacedemonians was deſtroyed by " an earthquake, and its ruins wholly buried by the moun- " tain Taygetus falling down upon them." Pliny's Nat. Hiſt. chap. lxxix.

16. " Many ſtrange effects enſue from earthquakes: " in one place the walls of cities are laid along; in ano- " ther they are ſwallowed up in deep and wide chaſms: " here are caſt up mighty heaps of earth; there, are " let out rivers of water, and ſometimes of fire; in ano- " ther place, the courſe of rivers are changed. The " chaſms ſometimes remain wide open, and ſhew what " hath been ſwallowed up; at other times they cloſe up

“ again, and conceal all that is contained in them, and “ no viſible marks thereof remain, notwithſtanding they “ have many times devoured cities, and whole tracts of “ land.” Ibid, chap. lxxx.

17. “ I found in the books of the Tuſcan learning, “ an earthquake recorded, which happened within the “ territory of Modena, when L. Martius and S. Julius “ were conſuls, which repeatedly daſhed two hills againſt “ each other. With this conflict, all the villages, and “ many cattle were deſtroyed; and this happened the “ year before the war of our aſſociates; which I doubt “ whether it were not more pernicious to the whole land “ of Italy than the civil wars. This event happened in “ the daytime, and was obſerved by many Roman gen“tlemen.” And,

18. “ No leſs a wonder happened in our age, in the “ very laſt year of Nero the emperor; when meadows “ and olive rows (notwithſtanding the great public port“way laid between them) paſſed into each others place, “ in the Marrucine territory.” Ibid, chap. lxxxiii.

19. “ The greateſt earthquake in man's memory was “ that which happened during the reign of Tiberius “ Cæſar, when twelve cities of Aſia were laid level in “ one night.” Ibid, chap. lxxxiv.

The preceding inſtances may ſerve to ſhew that mountains, cities, and large diſtricts of land, have been ſwallowed up from time to time, in various parts of the world; and others which have been clove aſunder, ſhivered to pieces, and their fragments thrown into the adjacent vallies; let us now inquire what other effects have been produced by theſe dreadful convulſions of nature.

20. "Thoſe famous iſlands Delos and Rhodes are "ſaid to have grown out of the ſea; and afterward "thoſe that were leſs, namely, Anaphe beyond Melos, "and Nea between Lemnus and Helleſpont. Alone, "alſo, between Lebedus and Peos. Thera likewiſe and "Theraſia, among the Cyclades, which firſt appeared "in the fourth year of the 135th Olympiad. More-"over among the ſame iſles, 130 years after, Hiera: "and two furlongs from it, after 110 years, Thia, "even in our time, upon the eighth day before the ides "of July, when M. Junius Syllanus, and L. Balbus "were conſuls." Pliny's Nat. Hiſt. chap. lxxxvii.

This truly eminent author has alſo recorded many other conſiderable alterations which have happened on the ſuperficial parts of the earth, at different periods of time; but, for brevity ſake, they are here omitted, being of ſuch remote antiquity. To proceed,

21. "In the year 726 the iſland Hiera was enlarged "to twice its former dimenſions by the addition of another iſland, which united ſo well to it, that there re-"mains no other mark of its joining than a cleſt or fiſ-

" ſure, which reaches from one end of the iſland to the " other, and in ſeveral places is not ſix inches wide. " And

22. " In the month of December, 1427, this iſland " called Hiera, or the Burnt Iſland, was again increaſed " by great rocks raiſed up by ſubterraneous fires. The " ſame thing happened again in the year 1457: but " with this difference, that the ſubterraneous fire, after " having raiſed to the height of five or ſix feet above the " water, a vaſt quantity of rocks, which formed a " ſpace about a mile in circumference, opened a paſ- " ſage for the ſea water to enter, by which it was extin- " guiſhed. And alſo

23. " In the year 1573 another iſland was formed, " called the Leſſer Burnt Iſland." Motte's Abridg. Phil. Tranſ. vol. ii. part. iv. p. 200.

24. " From the 24th of September to the 9th of " October, 1650, the iſland of Santirinum, formerly " called by Pliny Thera, was dreadfully ſhaken with " earthquakes, ſo that the inhabitants expected nothing " but utter ruin, and were yet more amazed to ſee a " horrid eruption of fire out of the bottom of the ſea, " about four miles to the eaſtward of the iſland; previ- " ous to the appearance of fire, the water was conſider- " ably elevated in that place, and the wave ſpreading " itſelf round every way, overturned every thing it met,

"deſtroying ſhips and galleys, in the harbour of Candia, "which was eighty miles diſtant. The eruption filled "the air with aſhes and horrible ſulphureous vapours, "and dreadful lightnings and thunders ſucceeded. All "things in the iſland were covered with a yellow ſulphureous "cruſt. Multitudes of pumice and other "ſtones were thrown up, and carried as far as Conſtantinople, "and to places at a great diſtance. The force "of this eruption was greateſt the two firſt months, "when all the neighbouring ſea ſeemed to boil; and the "volcano continually vomited up fire-balls: upon the "turning of the wind, great miſchief was done in the "iſland of Santirinum; many beaſts and birds were "killed: and on the 29th of October, and 7th of November, "fifty men were killed by it. The other four "months it laſted, though much abated of its former "fierceneſs, yet it ſtill caſt up ſtones, and ſeemed to "endeavour the making of a new iſland, which though "it do not yet perfectly appear above water, yet it is covered "but eight feet by the water. It is alſo ſaid, the "ſea, in that place was before fathomleſs." Dr. Hooke's Poſt. Work, p. 302.

25. "In the year 1707, another iſland was diſcovered, "where, it is ſaid, the ſea was eighty or a hundred "fathoms deep. This iſland continually increaſed in "height and breadth, for the ſpace of three years; in

"which time it became ſix miles in circumference, and "of conſiderable height. And,

26. "The iſland Santorini itſelf is ſaid to be compo-"ſed of burnt rocks and pumice-ſtones." Motte's Abr. Phil. Tranſ. vol. ii. part iv. p. 200.

27. "In the year 1628, one of the iſlands of the "Azores, near the iſland of St. Michael, roſe up from "the bottom of the ſea, which, in that place, was 160 "fathoms deep; and this iſland, which was raiſed in "fifteen days, is three leagues long, a league and a half "in breadth, and riſes 360 feet above the water." Sir William Hamilton's Obſervations on Veſuvius and Etna, p. 159.

28. "On the 20th of November 1720, a ſubterra-"neous fire burſt out of the ſea near Tercera, one of the "Azores, which threw up ſuch a vaſt quantity of "ſtones, &c. in the ſpace of thirty days, as formed an "iſland about two leagues diameter, and nearly round. "Prodigious quantities of pumice-ſtone and half-broiled "fiſh were found floating on the ſea, for many leagues "round the iſland." Eames' Abr. Phil. Tranſ. vol. vi. part ii. p. 203.

29. "Another example of the ſame kind happened "at Manilla, one of the Philippine iſlands, in the year "1750. This eruption was attended with violent "earthquakes, to which that iſland, as well as the reſt

"of the Philippines, is very much ſubject." Rev. Mr. Michell's Conjecture on Earthquakes, p. 16.

30. We may add to the above, the vaſt quantities of pumice-ſtones, which have been ſometimes found floating upon the ſea, at ſo great a diſtance from the ſhore, as well as from any known volcano, that there can be little doubt of their being thrown up by fires ſubſiſting under the bottom of the ocean.

31. "Mr. Garwin relates, that in the year 1726, a "Dutch captain ſailing above eighty leagues from the "Cape of Good Hope, found the ſea covered with "pumice-ſtones, through the ſpace of ſix hundred "leagues." Bertrand's Dict. of Foſſils, vol. ii. p. 126.

32. "In the year 1538, a ſubterraneous fire burſt "open the earth near Puzzoli, and threw up ſuch a vaſt "quantity of aſhes and pumice-ſtones, mixed with water, as covered the whole country, and thus formed "a new mountain, not leſs than three miles in circumference, and almoſt as high as mount Barbaro, near "a quarter of a mile perpendicular height. Some of "the aſhes of this volcano reached the vale of Diana, "and ſome parts of Calabria, which are more than 150 "miles from Puzzoli." Sir Wm. Hamilton's Obſervations, p. 128.

The few inſtances we have related of iſlands being raiſed in the ocean by ſubterraneous fires, ſtrengthen our conjectures concerning the origin of thoſe iſlands and mountains, which have a volcanic appearance, and are ſuppoſed to have been produced from the ſame cauſe, anterior to hiſtory, viz. Iceland, Fyal, &c. in the Northern Sea; St. Helena and Aſcenſion iſlands, between Africa and Braſil; Eaſter or Davis' iſland, Otaheite, &c. in the Southern Ocean; ſeveral of the Moluccas, in the Indian Sea; Madeira, ſeveral of the Azores and the Antilles, &c. in the Atlantic Ocean; the Lipari iſlands, Iſchai, &c. in the Mediterranean Sea.

The above may ſerve to put the reader in mind of recollecting many other iſlands which have ſimilar appearances; and likewiſe to ſhew that ſubterraneous fires actually exiſt under the bottom of the ocean, in various parts of the world; and that others may have been extinguiſhed time immemorial: let us therefore return to a more particular inquiry concerning the phenomena produced by ſubterraneous fires at land.

" 33. " The eruption of Veſuvius, in the year 79, " overwhelmed the two famous cities Herculaneum " and Pompeii, by a ſhower of ſtones, cinders, aſhes, " ſand, &c. and totally covered them many feet deep, " as the people were ſitting in the theatre. Herculaneum is ſaid to have been ſituate about four miles " from the crater, and Pompeii at the diſtance of ſix " miles; yet the latter appears to have been covered by

" that dreadful eruption ten or fifteen feet deep; and " the former, by that and ſubſequent eruptions lies buried ſixty or ſeventy feet deep. By the violence of this " eruption, aſhes were carried over the Mediterranean " Sea, into Africa, Egypt, and Syria; and at Rome they " choaked the air on a ſudden, ſo as to hide the face of " the ſun, to the great terror of the inhabitants, who " knew not the cauſe thereof, having not received the " news from Campania." Burnet's Sacred Hiſt. vol. ii. p. 85, 86.

34. " In the year 1632, rocks were thrown to the " diſtance of three miles from Veſuvius." Baddam's Abridg. Phil. Tranſ. vol. iii. p. 68.

35. " In the year 1631, a ſtone was thrown twelve " miles from the crater of Veſuvius, and fell upon the " Marquis of Lauro's houſe at Nola, which it ſet on " fire. And,

36. " In the year 1767, a ſolid ſtone, meaſuring " twelve feet in height, and forty-five in circumference, " was thrown a quarter of a mile from the crater of Veſuvius. The eruption of 1767, though by much the " moſt violent in this century, was, comparatively to " thoſe of the years 79 and 1631, very mild." Sir Wm. Hamilton's Obſervations, p. 49.

37. " In the year 1533, large pieces of rock were " thrown to the diſtance of fifteen miles, by the volcano

" Cotopaxi in Peru, and covered the plain of Latacunga; and near Hambato the earth opened in ſeveral " places, of which there ſtill remains an aſtoniſhing " monument, on the ſouth ſide of the town, being a " chaſm or cleft, four or five feet wide, and about a " league in length." Ulloa's Voyage to Peru, vol. 1. p. 324, 329.

38. " In 1669, ſtones of ſixty palms in length were " thrown from the crater of Etna, to the diſtance of " one mile, and ſtones of leſs ſize to the diſtance of three " miles. This eruption was accompanied by a great " darkneſs which continued many weeks. Alphonſus " Borelleus, a learned mathematician of Piſa, went into " Sicily, while the fact was freſh, to view and ſurvey " what Etna had done; and he ſays, the quantity of " matter thrown out at that time, upon ſurvey, amounted to 93,838,750 cubical paces; ſo that had it been " extended in length upon the ſurface of the earth, it " would have reached farther than 93,000,000 of ſuch " paces, which is more than four times the circuit of " the whole earth, taking 1000 paces to a mile: it is " true, all this matter was not liquid fire, but in part ſand, " ſtone, gravel, &c. however he computes 63,000,000 " paces of this matter were liquid fire, and formed a river, ſometimes two miles broad, according to his computation; but according to the obſervation of others,

" who alſo viewed it, the torrent of fire was ſix or ſeven
" miles broad, and ſometimes ten or fifteen fathoms deep,
" and it forced its way into the ſea near one mile, preſerving itſelf alive in the midſt of the waters. He likewiſe obſerves, that a ſtone fifteen feet long was flung
" out of the pit to a mile diſtance; and when it fell, it
" came from ſuch a height, and with ſuch violence, that
" it buried itſelf in the ground eight feet deep." Burnet's Sacred Theory, vol. ii. p. 82, 83.

39. " Olaus Wormius, a learned writer, gives an account of an earthquake in Iceland, which filled the air
" with duſt, earth, and cinders, and overwhelmed towns,
" fields, and even ſhips, a good way diſtant on the ſea;
" and which ſent forth its fumes with ſuch violence, and
" in ſuch quantities, as covered all the decks and ſails of
" ſhips lying on the coaſt of Norway, though not leſs than
" 600 miles diſtant." And,

40. Conſiderable as the above eruptions may appear, yet a much greater quantity of matter ſeems to have been thrown out by a volcano in Peru. " In the year 1600,
" an earthquake happened at Arequepa in Peru, accompanied with an eruption of ſand, aſhes, &c. which
" continued during the ſpace of twenty days, from a
" volcano breaking forth. The aſhes falling in many
" places above a yard thick, and in ſome more than two,
" and where leaſt above a quarter of a yard deep, which

" buried the corn-grounds of maize and wheat. The " boughs of trees were broken, and the cattle, great " and ſmall, died for want of paſture. For the ſand " and aſhes thus erupted, covered the fields 90 " miles one way, and 120 miles another way. From this account it appears that the ſpace of ground thus covered with ſand and aſhes was at leaſt equal to the area of a circle whoſe diameter is 210 miles; and its area, nearly equal to 34,636 ſquare miles: and ſince that ſpace was wholly covered from ſix feet to nine inches deep, *where leaſt*; we may thence infer that a much greater extent of ground was covered, though in a leſs degree. Theſe circumſtances being duly conſidered, may enable us, in ſome degree, to eſtimate the whole quantity of matter erupted, at 34,636 ſquare miles in breadth, and three feet in depth. The quantity of matter being thus computed exceeds that which flowed from Etna in the year 1669, upward of 1140 times. " During the above eruption which continued " near 20 days, mighty thunders and lightnings were " heard and ſeen, ninety miles round Arequepa: and " it was ſo dark while the ſhowers of aſhes and ſand " laſted, that at midday candles were burnt to do bu- " ſineſs." Dr. Hooke's Poſt. Work, p. 304.

41. " A mountain in Java, not far from the town " of Panacura, in the year 1586, was ſhattered to pieces

"by a violent eruption of glowing ſulphur (though it "had never burnt before) whereby 10,000 people periſhed in the under-land fields. It threw up large "ſtones, and caſt them as far as Pancras." Varenius' Geog. vol. i. p. 150.

Thus the fragments of the ſtony *ſtrata*, together with ſand, aſhes, &c. have been ſpread over the ſurface of the earth at ſundry periods of time, by means of ſubterraneous convulſions; and therefore, ſince there are no other operations in nature yet known, whence ſuch effects have been produced, may we not thence infer, that all ſimilar appearances on the ſuperficial parts of the earth have ariſen from ſimilar cauſes; notwithſtanding there are no veſtiges of ancient volcanos now remaining, in many parts of the world where the fragments of the *ſtrata* are thus ſcattered about.

Were it poſſible to enumerate all the exiſting volcanos in the different regions of the earth, together with thoſe which have been apparently extinguiſhed time immemorial, and likewiſe the many inſtances we have had of new volcanos burſting forth, not only in various parts of continents and iſlands, but alſo in the bottom of the ocean, we ſhould be apt to conclude, that ſubterraneous fires either do, or have heretofore exiſted univerſally in the bowels of the earth.

We have therefore much reaſon to infer, from the great analogy which prevails between the effects produced by thoſe ſtupendous operations of nature, and the romantic appearances on the ſuperficial parts of the earth, deſcribed Chap. VIII, that the latter were as certainly the effects of ſubterraneous fires as the former.

It muſt however be owned, that notwithſtanding the great analogy between the real effects produced by ſubterranean convulſions, and the appearances obſerved on the ſurface of the earth, that the former, when compared with the latter, as the Alps, the Andies, &c. in point of magnitude, they ſeem to vaniſh, or become too inconſiderable to ſtand in competition with them.

Whence it appears, that ſubterraneous convulſions operated more violently in the early ages of the world, than they have done ſince the commencement of records.

CHAP. X.

Of the Alterations produced on the ſuperficial Parts of the Earth anterior to Hiſtory.

IN the preceding chapter we have endeavoured to enumerate ſome of the moſt conſiderable alterations which have been produced on the ſuperficial parts of the earth by ſubterraneous convulſions, ſince the commencement of hiſtory, in order to obſerve the analogy between thoſe effects, and the general ſtate and condition of the terraqueous globe, with reſpect to its craggy rocks, mountains, vallies, and all other diſorderly appearances, and from thence to infer the general cauſe of thoſe inequalities.

Whence it appears, that, notwithſtanding the ſtupendous effects produced by ſubterraneous convulſions ſince the commencement of hiſtory, they are much inferior to thoſe produced anterior to any hiſtorical monument whatever; as the following inſtances abundantly teſtify. Let us therefore proceed to ſuch obſervations as have a tendency to eſtabliſh the effects above ſuggeſted.

Theſe remote operations of nature already mentioned, ſeem to have but recently attracted the attention of European philoſophers, though ſo eſſentially neceſſary to the inveſtigation of many natural phenomena, on the ſuperficial parts of the earth.

M. Condamine ſeems to have been the firſt naturaliſt who has favoured the world with any obſervations on this ſubject: for although Italy has been conſidered as the ſeat of learning and polite arts for many centuries, and has been viſited as ſuch, by all the learned of Europe; yet the natural hiſtory thereof ſeems not to have been the object of inquiry before the year 1755. Since that period the ſubject has been reſumed by Sir William Hamilton, his majeſty's plenipotentiary at the court of Naples, and carried to a much greater length.

However, ſince the obſervations of M. Condamine are truly ingenious, and alſo prior to thoſe of Sir William Hamilton, we think it a compliment due to that celebrated naturaliſt, to give them the firſt place in the preſent reſearches. The former, in his tour to Italy in the year 1755, writes thus,

" All the mountains and hills about Naples, will be " found, upon examination, to be huge heaps of mat- " ter, vomited out by volcanos, which are now extinct, " whoſe eruptions, anterior to hiſtory, ſeem to have " formed the ports of Naples and Puzzoli. It is not in " Naples alone, and its neighbourhood, that I have met " with ſuch like ſubſtances. As my eyes have been ac- " cuſtomed to diſtinguiſh the different emanations of " Veſuvius, and eſpecially the lava, under its variety of " aſpects, I could trace it with eaſe and certainty the " whole way from Naples to Rome, even to the very " gates of the latter, ſometimes pure, and again com- " bined with other ſubſtances.

" The whole inſide of the mountain Fraſcati, where " was Cicero's Tuſculum ; the chain of hills which ex- " tend from Fraſcati to Grotta-Ferrata, Caſtel-Gon- " dolſo, and even to the lake Albano ; a good part of " the mountain Tivoli ; thoſe of Capravola, Viterbo, " &c. conſiſt of beds of calcined ſtones, pure aſhes, " cinders, gravel, a ſubſtance like iron droſs, terra-

"cotta, and lava properly ſo called: in a word, ſo "like, in all reſpects, to the compoſition of the ſoil of "Portici, and to the materials which have iſſued out of "the ſides of Veſuvius, under ſuch a diverſity of forms, "that the ſight alone is ſufficient to diſtinguiſh all theſe "ſeveral ſubſtances. The aſhes are manifeſt, both from "their colour and taſte. It is impoſſible for any one "who has attentively examined the productions of Veſuvius, "not to be ſatisfied of a perfect reſemblance be"tween them and thoſe he will meet with at every ſtep, "in his way from Naples to Rome, from Rome to Viterbo, "from Rome to Loretto, &c.

"It then neceſſarily follows, that all this part of Italy "has been ruined by volcanos. Thoſe plains, now ſo "ſmiling and fertile in olive-trees, mulberry-trees, and "vines, like the hills at preſent about Veſuvius, have "like them been overſpread with burning inundations, "and bear, as they do, not only within, but on their "ſurface, infallible marks of fiery torrents, whoſe waves "are now fixed and conſolidated, bearing teſtimony of "vaſt ignitions, prior to all monuments of hiſtory.

"When I ſee, on an elevated plain, a circular baſin, "ſurrounded with calcined rocks; the verdure with "which the neighbouring fields are covered, impoſe not "on me: I inſtantly perceive the ruins of an ancient "volcano, as I ſhould perceive, beneath the ſnow itſelf,

“ the traces of an extinguiſhed fire, on ſeeing a heap “ of cinders.

“ If there be a breach in the circle, I uſually find out, “ by following the declivity of the ground, the traces of “ a rivulet, or the bed of a torrent, which ſeems as it “ were hollowed in the rock; and this rock, when examined cloſely, appears frequently to be nothing more “ than lava, properly ſo called.

“ If the circumference of the baſin has no breach, the “ rain and ſpring waters which aſſemble there having no “ iſſue, generally form a lake in the very mouth of the “ volcano.

“ A few days after the ſight of the lake Albano itſelf “ (and the calcined matter with which its banks are “ powdered, left no room to doubt any longer of its “ origin) I ſaw manifeſtly the profound funnel or ſhaft “ of an ancient volcano, in the mouth of which the “ waters had accumulated themſelves. Its eruption, of “ which hiſtory makes no mention, muſt have been anterior to the foundation of Rome, and even of Alba, “ from whence this lake has taken its name: a period “ amounting to near three thouſand years.

“ At the ſight of the traces of fire diffuſed in the environs of the lakes of Borſello, de Rociglione, and Bracciano, on the road from Rome to Florence, I had “ formed the ſame conjectures, before I had ſeen either

" Veſuvius, or the matter which it vomits forth. I paſs " the ſame judgment by analogy, on the lake Perugia, " and ſeveral others in the interior part of Italy, which " I only know by the map.

" In ſhort, I look upon the Apennines as a chain of " volcanos, like that of the Cordeliers of Peru and Chily, which run from north to ſouth, the whole length " of South America, from the province of Quito to the " Terra Magellanica.

" The courſe of the volcanos of the Cordeliers is interrupted; a great number of them are either extinguiſhed or ſmothered, but ſeveral ſtill remain actually " burning. The old ones alſo frequently revive, and " ſometimes new ones are kindled, even in the bottom " of the ſea. Nor are their effects, on that account, " leſs fatal.

" A few years ſince both Lima and Quito, two capital cities of Peru, became the victims of thoſe two " kinds of volcanos.

" The chain of the Apennines which divides the continent of Italy, in like manner from north to ſouth, and " extends as far as Sicily, preſents us ſtill with a pretty " great number of viſible fires under different forms.

" In Tuſcany the exhalations of Firenzuolo, and the " warm baths of Piza; in the eccleſiaſtical ſtate, thoſe

“ of Viterbo, Norcia, Nocera, &c. in the kingdom of
“ Naples, thoſe of Iſchia, Solfatarra, Veſuvius; in Si-
“ cily and the neighbouring iſles, Etna, or mount Gi-
“ bel, with the volcanos of Lipari, Stromboli, &c.
“ But other volcanos of the ſame chain, having been quite
“ extinguiſhed from time to time immemorial, have left
“ only ſome remains behind, which though they may
“ not always ſtrike at firſt ſight, are not at all leſs diſtin-
“ guiſhable to attentive eyes.

“ In ſhort, the earthquakes which at various times
“ have overrun ſeveral of the cities of Italy and Sicily;
“ that which ſwallowed up St. Euphemia in 1538; that
“ which deſtroyed Catana in 1693; that which opened
“ the gulphs of Palermo in 1718; and that which over-
“ run Syracuſe, recall to my remembrance the diſaſters
“ of Valparaiſo, Callao, Lima, and Quito, in South A-
“ merica, and cloſe the parallel between the Cordeliers
“ of Italy and thoſe of Peru: the features of reſemblance
“ are but too ſtriking.

“ I do not affirm that all mountains are in the caſe of
“ the Apennines; I could not obſerve the ſame appear-
“ ances in that part of the Alps which I travelled over;
“ but I have found the ſame in Dauphiny, Provence,
“ and ſeveral places where they were never looked upon
“ as the effects of fire. It is not therefore in Italy alone
“ that the veſtiges of calcination and vitrification are to
“ be

" be met with, but alſo in places where volcanos have " never been ſuppoſed to have exiſted; France affords " inſtances, and poſſibly moſt countries. My conjectures " about the ancient volcanos of Italy, of which I find " marks in all parts, and on the lava, which I diſcovered even in places where I the leaſt expected it, appear " to me ſo evident, that my only wonder was, they " ſhould be new. They were however looked upon as " whims, in a country, where I ſtill think, nothing " more than the uſe of one's eyes is neceſſary to produce " the like," &c.

Thus far the obſervations of M. Condamine; which are happily confirmed by thoſe of Sir William Hamilton, who has alſo added many new and intereſting obſervations on the ancient volcanos of Italy.

" It would require," ſays Sir William, " many years " cloſe application to give a proper and truly philoſophical account of the volcanos in the neighbourhood of " Naples; but I am ſure ſuch a hiſtory might be given, " ſupported by demonſtration, as would deſtroy every ſyſtem hitherto upon the ſubject. We have here an opportunity of ſeeing volcanos in all their different ſtates. I " have been this ſummer in the iſland of Iſchia; it is " about eighteen miles round, and its whole baſe is lava. " The great mountain in it, near as high as Veſuvius, I " am convinced, was thrown up by degrees; and I have

" no doubt in my own mind, but that the iſland itſelf " roſe out of the ſea; in the ſame manner as ſome of " the Azores. I am of the ſame opinion with reſpect " to mount Veſuvius, and all the high grounds near " Naples; having not yet ſeen in any place, what can " be called virgin earth. I had the pleaſure of ſeeing a " well ſunk at the foot of Veſuvius, and cloſe by the ſea " ſide. At twenty-five feet below the level of the ſea, " they came to a *ſtratum* of lava, and God knows how " much deeper they might have ſtill found other lavas.

" At the convent of the Dominican friars, called Ma- " dona del Arco, ſome years ago, in ſinking a well, 100 " feet deep, a lava was diſcovered, and ſoon after ano- " ther; ſo that in leſs than 300 feet deep, the lavas of " four eruptions were found. From the ſituation of this " convent, it is clear, beyond a doubt, that thoſe lavas " proceeded from the mountain called Somma, as they " are quite out of the reach of the exiſting volcano.

" From theſe circumſtances, and from the repeated " obſervations that I have made in the neighbourhood " of Veſuvius, I am ſure no virgin ſoil is to be found " there, but that all is compoſed of different *ſtrata* of " erupted matter, even to a great depth below the level " of the ſea. In ſhort, I have not any doubt in my " own mind, but that this volcano took its riſe from " the bottom of the ſea; and as the whole plain be-

“ tween Veſuvius and the mountains behind Caſerta, “ which is beſt part of Campania-Felice, is under its “ good ſoil compoſed of burnt matter; I imagine the “ ſea to have waſhed the feet of thoſe mountains, until “ the ſubterraneous fires began to operate, at a period “ certainly of the moſt remote antiquity.

“ The mountains at the back of Caſerta are moſtly “ a ſort of limeſtone, and therefore very different from “ thoſe formed by fire; though Signor Van Vitelli, “ the celebrated architect, has aſſured me, that in cut-“ ting the famous aqueduct of Caſerta through thoſe “ mountains, he met with ſome ſoils that had been “ evidently formed by ſubterraneous fire.” Sir William Hamilton’s Obſervations.

“ In the year 1689, as ſome workmen were digging “ a well near the foot of mount Veſuvius, a mile from “ the ſea, in the ſpot where formerly ſtood the famous “ city of Pompeia, I obſerved, ” ſays Francis Bianchini, a celebrated architect, “ clodded earth and vitrified “ ſtone were laid in regular alternate *ſtrata*, in the “ following order, viz.

	Palm.		Feet.	Inches.
1. Cultivated Earth	12	=	10 .	0
2. Black vitrified Stone	4	=	3 ·	4
3. Solid Earth	3	=	2 .	6
4. Vitrified Stone	6½	=	5 ·	5
	25½	=	21 ·	3

“ Under the fourth *ſtratum* were found ſome coals, iron door locks, and two inſcriptions ſignifying that the city of Pompeia formerly ſtood there.—Proceeding further, the following *ſtrata* were obſerved.

	Palm.		Feet.	Inches.
5. Solid Earth	10	=	8 .	4
6. Vitrified Stone	2½	=	2 .	1
7. Earth ſtiffer than the former	8	=	6 .	8
8. Vitrified Stone	4	=	3 .	4
9. Earth more indurated	25	=	20 .	10
10. Vitrified Stone very heavy	16	=	13 .	4
11. Soft Stone	14	=	11 .	8
	79½	=	66 .	3

“ Under which *ſtratum*, ſuch plenty of water flowed into the well as put a final ſtop to any further reſearches.

“ The two inſcriptions found at the depth of 25½ palms, or twenty-one feet three inches, together with the coals and iron works, carry with them ſuch teſtimony that the Romans inhabited that plain, as perſuade one to believe that the *ſtratum* No. 4. proceeded from the eruption which occaſioned the death of Pliny.”

Therefore the *ſtrata* N°. 6, 8, and 10, if not thoſe N°. 5, 7, and 9, proceeded from eruptions much anterior to the foundations of Herculaneum and Pompeia; though the former is ſaid to have been built by Hercules, who is ſuppoſed to have been cotemporary with Abraham,

ham, in the year of the world 2240, near 2000 years prior to their deſtruction in the 79th year of the Chriſtian era.

The alternate *ſtrata* of lava and ſoil have been conſidered as ſufficient data, for proving the antiquity of the world; taking for granted that the quantity of ſoil contained in each *ſtratum*, to have been produced by length of time only; not conſidering that eruptions of ſand, aſhes or mud, are equally frequent with thoſe of liquid fire, and that ſuch productions become immediately fit for vegetation. Hence the reſult of ſuch reaſonings are rendered fallacious: for although a quantity of ſoil may accumulate upon a bed of lava in the ſpace of ſeveral ages, yet ſince there are other means whereby lava becomes covered with ſoil, as in the inſtances already named, it appears much more probable that the *ſoil ſtrata*, proceeded from ſubſequent eruptions, than from length of time. But theſe obſervations are rather a digreſſion from the ſubject. Therefore to return.

Among the numerous veſtiges of ancient volcanos, I preſume there are few more ſtupendous than thoſe on the northern coaſt of Ireland, though no viſible crater is now remaining between Port Ruſh Strand and Balley Caſtle eaſtward; a diſtance nearly equal to 20 miles Engliſh, and yet, the whole of that ſpace is one continued maſs of lava; and I have been credibly informed that the ſame appearances extend many miles from Port Ruſh toward the weſt.

The cliffs are indeed truly ſtupendous, and bear every poſſible mark of their having been originally liquid fire. The elevation of that at the foot of which the Giants Cauſeway is ſituate, we preſume cannot be leſs than five or ſix hundred feet perpendicular height above the Atlantic Ocean, and yet compoſed intirely of lava: and the ſame appearances extend from thence toward the ſouth, upward of twenty miles.

As we purpoſe giving ſome further account of theſe ancient eruptions in Chap. XXIV. together with a ſection of the *ſtrata*, we poſtpone many other particulars, with reſpect to theſe wonderful operations, till we arrive at that part of the work.

We might have enumerated many other inſtances, tending to prove the antiquity and powerful effects of ancient volcanos; but we preſume the above may ſerve to evince the truth of ſuch a conjecture: however, as the ſubject is a matter of ſome importance, we ſhall endeavour to ſhew, that ſuch operations of nature were conſequences neceſſarily ariſing from the ſtate and condition of the earth, at thoſe remote periods of time. But previous to that inquiry, it becomes requiſite to lay before the reader, ſundry phenomena, relative to the cauſe and effects of earthquakes.

CHAP. XI.

Of ſundry Phenomena relative to the Cauſe and Effects of Earthquakes.

1. PREVIOUS to an eruption of Veſuvius, the earth trembles, and ſubterraneous exploſions are heard. The ſea likewiſe retires from the adjacent ſhore till the mountain is burſt open, then returns with impetuoſity, and overflows its uſual boundary. Such undulations of the ſea are not uncommon, but frequently precede the eruptions of Veſuvius. Neither are they peculiar to that mountain, but have been notorious in many other parts of the world, as the following inſtances evidently ſhew.

2. On the firſt of November 1755, the era ſo fatal to Liſbon, the iſland of Madeira was violently ſhook by an earthquake, attended by ſubterraneous exploſions. And about an hour and half after the tremor had ceaſed, the ſea, which was quite calm, retired ſuddenly ſome paces from the ſhore; and returning with a great ſwell entered the city of Funchal: the water roſe full fifteen feet above highwater mark, although the tide which ebbs and flows ſeven feet was then at half ebb; the water immediately receded again, and having fluctuated four

or five times between high and low water mark, the undulations ceaſed, and the ſea became quite calm as before. In the northern part of this iſland the undulations were more violent: for the ſea retired at firſt above one hundred paces, and ſuddenly returning overflowed the ſhore; deſtroying or damaging ſeveral houſes or cottages. Great quantities of fiſh were left on ſhore, and in the ſtreets of the village of Machico. All this was the effect of one ſole undulation; for the ſea never flowed afterward ſo high as highwater mark, although the fluctuations continued much longer there than at Funchal. Weſtward the fluctuations were hardly perceptible.

3. The earthquake which deſtroyed Liſbon on the firſt of November 1755, was preceded by a rumbling noiſe, which increaſed to ſuch a degree as to equal the exploſions of the loudeſt cannon. About an hour after the ſhocks, the ſea was obſerved from the high grounds to come ruſhing toward the city like a torrent, though againſt wind and tide; it roſe forty feet higher than was ever known, and ſuddenly ſubſided. A ſhip 50 leagues off at ſea received ſo violent a ſhock as greatly injured the deck.

4. On the firſt of November 1755, Cadiz was alſo violently ſhook by an earthquake, which threw the inhabitants into great conſternation. An hour after, they

were yet more alarmed at the appearance of a wave eight miles off, coming toward the town, which was at leaſt ſixty feet higher than common. The inhabitants began to tremble, and the centinels left their poſts. It came againſt the weſt part of the town, which is very rocky, and the rocks abated a great deal of its force; but at laſt it came againſt the walls, beat in the breaſtwork, and carried pieces of eight or ten ton weight, forty or fifty yards from the wall. Every one now thought the town would be ſwallowed up; for although this tide was run off, yet with glaſſes they ſaw more coming. When the wave was gone, ſome parts that were deep at low-water were quite dry; for the water returned with the ſame violence as it came. Theſe waves came in this manner four or five times, but with leſs force each time.

Another account ſays, that the inhabitants had ſcarce begun to recover from their firſt terror when they ſaw themſelves plunged into new alarms. At ten minutes after eleven they ſaw rolling toward the city, a tide of the ſea, which paſſed over a parapet of ſixty feet above the ordinary level of the water: at thirty minutes after eleven came a ſecond tide; and theſe two were followed by four others of the ſame kind, viz. at fifty minutes after eleven, thirty minutes after twelve, ten minutes after one, and fifty minutes after one. The tides continued,

tinued, with ſome intervals, till evening. They ruined 100 toiſes, or 600 feet of the rampart; part of which, of three toiſes length and of their intire thickneſs, was carried by the torrent above fifty paces.

5. The ſame day and hour, the ſea came up to the walls of Tangier, a thing never known before, and returned with the ſame rapidity as it came up, leaving upon the mole a great quantity of ſand and fiſh. Theſe commotions of the ſea were repeated eighteen times, and continued till ſix in the evening, though with leſs violence than the firſt time.

6. The ſame phenomena happened at Arzila; the water came in through one of the city gates very far, with great impetuoſity; and a boat was found at the diſtance of two muſket ſhots from the ſea.

7. At Salle the waters came up with great rapidity into the city; and at their return great quantities of fiſh were found in the ſtreets. Many perſons were drowned, and a large number of camels were carried away by the flood.

8. Saffe fared little better; the ſea came up as far as the great moſque, which is within the city, and at a great diſtance from the ſea.

9. Such were the agitations of the ſea in foreign parts on the firſt of November 1755. And the ſame phenomena were obſerved on the ſame day, but in a leſs degree, at

Plymouth, Portſmouth, Mounts Bay, Penzance, Swanzea, Yarmouth Haven, Hull, Gainſborough, &c. in England; likewiſe in Scotland, Ireland, and Holland. And it was not the ſea only which was thus violently agitated, but confined waters in various parts of England and the continent: namely a pool at Balborough in Derbyſhire, another at Foremark, ſeveral at Haynor, &c. Likewiſe many pieces of water in Kent, Surry, Suſſex, Eſſex, Berkſhire, Oxfordſhire, &c. At moſt of theſe places, the waters were ſo violently agitated as to overflow their banks.

10. The ſame fluctuations of waters were obſerved on ſeveral lakes on the continent: namely the lakes of Geneva, Zurich, Neufchatel in Switzerland, and at Lyons.

11. At Rotterdam, the branches in a church were obſerved to oſcillate as a pendulum; and ſo were the candles in a chandler's ſhop at Hague.

12. And we are alſo told, that it is no uncommon thing to ſee the ſurface of the earth undulate as waves of the ſea, at the time of theſe dreadful convulſions of nature.

Many other intereſting phenomena relative to that tremendous earthquake on the firſt of November 1755, are recorded in the Philoſophical Tranſactions, vol 49. part 1. but for the ſake of brevity they are omitted.

The appearances above related were not peculiar on the firſt of November 1755; for we have ſeveral other notorious inſtances recorded; namely,

13. In the year 1746, Callao, a conſiderable garriſon town and ſeaport in Peru, containing 5000 inhabitants, was violently ſhook by an earthquake on the 28th of October. And the people had no ſooner begun to recover from the terror occaſioned by the horrid convulſion, but the ſea rolled in upon them in mountainous waves, and put a final period to their exiſtence: for they all periſhed except 200, who were providentially ſaved on board of ſhips and fiſhing boats lying in the harbour. The elevation of this extraordinary tide was ſuch as conveyed ſhips of burden over the garriſon walls, the towers and the town, diſtant from the ſea: one in particular which arrived from Chili the preceding day, was conveyed to the foot of the mountains, and there remained on dry ground. The flood of water flowed over the town with ſuch rapidity, that it tore up the foundations of all the buildings, except thoſe of the two grand gates, and ſome few parts of the garriſon walls, which remain as the only monuments of that dreadful cataſtrophe. All the other parts of the town were ſo completely eraſed, and the parts covered by ſand and gravel, as totally concealed the appearance of a town having

ever exiſted upon the ſpot of ground where Callao ſtood. See Relation of Earthquakes by T. Oſborne, 1748.

14. Another inſtance, ſomewhat ſimilar to the above, happened the 29th of September 1535, previous to an eruption near Puzzola, which formed a new mountain three miles in circumference, and upward of 1200 feet perpendicular height: for the earth was frequently ſhook, and the plain lying between the lake Averno, mount Barbaro, and the ſea, was raiſed a little: at the ſame time the ſea which was near the plain, retired 200 paces from the ſhore, and left many fiſh a prey to the inhabitants of Puzzola. See Sir William Hamilton's Obſervations on Veſuvius.

The preceding undulations of the ſea and other waters, together with the undulatory motion of the earth's ſurface, and the oſcillation of pendulous bodies, are phenomena which ariſe from the expanſive force of ſteam generated in the bowels of the earth; as we ſhall endeavour to prove hereafter from a ſeries of undeniable facts.

The facts particularly alluded to, are eruptions of boiling water and ſteam, in various parts of the world, but eſpecially in the vicinity of volcanos. Of which the Rev. Dr. Uno Von Troil, in his Letters on Iceland, has recorded many curious inſtances, as follow.

"Near Laugervarn, a ſmall lake about a mile in "circumference, which is two days journey diſtant from "Hecla, I ſaw the firſt hot ſpouting ſprings, and I "muſt confeſs that it was one of the moſt beautiful ſights "I ever beheld. The morning was uncommonly clear, "and the ſun had already begun to gild the tops of the "neighbouring mountains; it was ſo perfectly calm, "that the lake on which ſome ſwans were ſwimming was "as ſmooth as a looking-glaſs, and round about aroſe "in eight different places the ſteam of the hot ſprings, "which loſt itſelf high in the air.

"Water was ſpouting from all theſe ſprings, but one "in particular continually threw up a column from 18 "to 24 feet high, and from ſix to eight feet diameter; "the water was extremely hot. A piece of mutton "and ſome ſalmon trout were almoſt boiled to pieces in "ſix minutes, and taſted excellently.

"At Reikuin was another ſpout of the ſame ſort; the "water of which, I was aſſured, roſe to ſixty or ſeventy "feet perpendicular height ſome years ago; but a fall "of earth having almoſt covered the whole opening, it "now ſpouted only between 54 and 60 feet ſidewiſe.

"At Geyſer, not far from Skallott, a moſt extraordi-"nary large ſpouting fountain is to be ſeen.

"One ſees here within the circumference of half a "mile, or three Engliſh miles, 40 or 50 boiling ſprings

" together: in ſome the water is perfectly clear, in " others thick and clayey; in ſome, where it paſſes " through a fine ochre, it is tinged red as ſcarlet; and " in others, where it flows over a paler clay, it is white " as milk.

" The water ſpouts up from ſome continually, from " others only at intervals. The largeſt ſpring, which is " in the middle, particularly engaged our attention the " whole day, from ſix in the morning till ſeven at night. " The aperture through which the water roſe was 19 " feet in diameter: round the top of it is a baſin, which, " together with the pipe, hath the form of a caldron; " the margin of the baſin is upward of nine feet one " inch higher than the conduit, and its diameter 56 " feet. Here the water does not ſpout continually, but " only by intervals ſeveral times a day: and as I was informed by the people in the neighbourhood, in bad " rainy weather higher than at other times.

" On the day we were there, the water ſpouted at " ten different times, from ſix in the morning till eleven " A. M. each time to the height of between 30 and 60 " feet: till then the water had not riſen above the margin of the pipe, but now it began by degrees to fill " the upper baſin, and at laſt it run over. We were " told by the people with us, that the water would ſoon " ſpout much higher than it had yet done; which ac-

"count appearing credible to us, Dr. Lind ſet up his "quadrant, in order to aſcertain the elevation thereof "with the utmoſt accuracy. Soon after four o'clock, "we obſerved the earth begun to tremble in three dif- "ferent places, and particularly at the top of a mountain, "which was about ſix hundred yards diſtant from the "mouth of the ſpring; we alſo frequently heard a ſub- "terraneous noiſe like the exploſion of cannon; imme- "diately after which, a column of water ſpouted from "the aperture, which at a great diſtance divided itſelf "into ſeveral parts, and according to the obſervations "made with the quadrant was 92 feet high. Our great "ſurprize at this uncommon force was yet increaſed, "when many ſtones which we had thrown into the a- "perture, returned with the ſpouting water."

The numerous fountains of boiling water which the Doctor obſerved in his tour through Iceland, together with thoſe in Italy, the iſland of St. Miguel, and other volcanic regions of the earth, which either flow continually or by intervals; and likewiſe thoſe of ſteam only; are ſome of the many phenomena attendant upon ſubterraneous convulſions. We ſhall therefore endeavour to inveſtigate the cauſe of thoſe appearances in due time. But among the various operations of that kind, few are more aſtoniſhing, or more inſtructive than the following, viz.

In the years 1631 and 1698, vaſt torrents of boiling water flowed from the crater of Veſuvius, previous to an eruption of fire. And what was very remarkable, many ſorts of calcined ſeaſhells were found upon the brink of the crater, alſo in the channel formed by the flood. The former eruption was ſo conſiderable that the violence of the flood ſwept away ſeveral towns and villages, and ſome thouſands of inhabitants. And,

In the year 1755, a dreadful torrent of boiling water flowed from the crater of Etna, at the time of an eruption of fire. See Sir William Hamilton's Obſervations.

The ſeaſhells which accompanied the above eruptions, evidently teſtify, that a communication had been opened between the two oceans of melted matter and water, inſomuch that it ſeems altogether needleſs to add any thing more in confirmation of the fact.

The preceding facts, relative to eruptions of ſteam and boiling water, we conſider as the principal data upon which all the phenomena relative to ſubterraneous convulſions depend: therefore ſome attempt to illuſtrate the mechanical cauſe thereof may be acceptable to ſeveral of our readers.

Let Plate VI. fig. 3. repreſent the ſection of a cavernous mountain, ſituate within the influence of a ſubterraneous fire. And let A repreſent a cavern containing water;

water, with a communication to the external air through the fiſſure C. And let us alſo ſuppoſe that the cavern A is ſupplied with water from the caverns B B, which communicate with A by the intermediate fiſſures repreſented in the ſection.

Matters being thus circumſtanced, the following effects will neceſſarily ariſe: namely, as the water in the cavern A becomes intenſely heated, a conſiderable part thereof will become converted into ſteam, and having no vent or communication with the external air, but through the fiſſure C, the expanſive force of the ſteam will act on the ſurface of the water with ſo much violence, as to occaſion a fountain as repreſented at F. And this fountain will act with more or leſs force according to the degree of reſiſtance the water meets with: for ſuch as the reſiſtance is, ſuch will be the degree of rarefaction, and the expanſive force of the ſteam, provided the fire is ſufficiently near to the water.

Now if the quantity of water received into the cavern A in a given time, is not equal to that diſcharged, ſuch fountains cannot act perpetually, but by intervals.

But in ſuch caſes, wherein the quantities received and diſcharged are equal, ſuch fountains will flow without intermiſſion; other circumſtances being equal.

Again; if the expanſive force of ſteam acts with ſo much violence as to obſtruct the inlets of water from

B B, the cavern A will become the ſooner exhauſted, and the time of eruption ſhortened.

The water being thus totally driven out of the cavern, the ſteam follows, and ſoon reſtores the equilibrium of the expanſive force. The force of the ſteam being thus deſtroyed, the water deſcends from the caverns B B, and repleniſhes the cavern A with cold water.

To the above, and many other ſimilar cauſes, may be aſcribed eruptions of *water*, *liquid fire*, *ſteam*, and all other materials before mentioned; we may therefore conclude, that fire and water are the primary agents concerned in all ſuch operations of nature: for if we ſuppoſe melted matter contained in the cavern A, the force of the ſteam would occaſion an eruption of liquid fire; for the expanſive force of the fire would elevate the incumbent weight, and thereby open the communication from A to B B. Hence the water contained in B B would deſcend into the cavern A, and become converted into ſteam, and produce the effects before deſcribed.

Theſe few hints may ſerve to convey ſome idea of the cauſe whence eruptions of various kinds proceed.

In ſuch inſtances wherein ſteam only evacuates continually, there muſt be a communication between the external air and the ſurface of the water; as if it were a caldron of boiling water. Such communications therefore counteract the force of the ſteam, and prevent its powerful effects, which we have already obſerved exceeds the force of gunpowder as 14,000 is to 500.

The following inſtance may ſerve in ſome degree to ſhew the powerful effects of water converted into ſteam by liquid fire; truths well known to founders converſant in caſting of gold, ſilver, copper, braſs, or iron. "About ſixty years ago, a melancholy accident hap-"pened from the caſting of braſs cannon at Windmill-"hill Moorfields, where many ſpectators were aſſem-"bled to ſee the metal run into the moulds. The heat "of the metal of the firſt gun drove ſo much damp "into the mould of the ſecond, which was near it, that "as ſoon as the metal was let into it, it blew up with "the greateſt violence, tearing up the ground ſome feet "deep, breaking down the furnace, untiling the houſe, "killing many people on the ſpot with the ſteams of "melted metal," &c. See Cramer's Art of aſſaying Metals, p. 323.

To the ſudden rarefaction and condenſation of ſteam, may be aſcribed the tremour or ſhaking of the earth; and alſo the violent ſubterraneous exploſions which generally precede the eruptions of Etna and Veſuvius.

We may add to the above, that ſince there are many ſprings in Iceland, the iſland of St. Miguel, and many other volcanic regions of the earth, the temperatures of which vary from each other from 48° to 212°; may we not thence infer, that all tepid and hot ſprings, which flow in ſuch regions, owe their various temperatures to ſubterraneous fires.

Now if the above conjectures are true, the preſumption is great, that all tepid and hot ſprings, whether in volcanic, or other region, wherein there are no exiſting volcanos, do nevertheleſs derive their various degrees of heat from a ſimilar cauſe.

Hence the ſprings at Bath, Buxton, and Matlock, may derive their temperatures from ſubterraneous fires, although there are no exiſting volcanos in England.

Such are the general phenomena relative to the cauſe and effects of earthquakes. Whence we may venture to infer, without enumerating the various circumſtances, that fire and water are the principal agents employed in all thoſe dreadful operations of nature: namely, the undulations of the ſea and other waters before mentioned; together with the undulatory motion of the earth's ſurface; are all of them wholly owing to the expanſive force of ſteam, generated in the bowels of the earth, by means of ſubterraneous fire. And we may likewiſe aſcribe all other eruptions, whether of *fire*, *water*, *mud*, *aſhes*, *ſand*, &c. to the ſame cauſe: for although inflammable air, or the damp in mines, occaſion violent exploſions; yet ſuch exploſions are only momentary, like the firing of gunpowder; whereas volcanic eruptions explode inceſſantly with great violence, many weeks, or months together. Hence their operations become ſo very analogous to the effects of the elopile, that we are much inclined to attribute their different effects to one and the ſame cauſe, as before aſſigned.

Having premiſed theſe matters, we ſhall endeavour to inveſtigate, from the ſame principles, the cauſe of an univerſal flood, the origin of mountains, continents, craggy rocks, cliffs, and ſuch other diſorderly appearances on the ſurface and interior parts of the earth. We ſhall alſo inquire into the cauſe of ſubterraneous convulſions acting more violently in the early ages of the world, than within the laſt period of three or four thouſand years.

CHAP. XII.

Of ſubterraneous Fire, and its Effects on the incumbent Strata, from the firſt Increment of Heat to its full Maturity. Of the Deluge. Of the Origin of Mountains, Continents, &c. Of the Improbability of a ſecond univerſal Flood.

THE numberleſs inſtances we find recorded of volcanos and their effects, leave no room to doubt the exiſtence, force, and immenſity of ſubterraneous fires; not only under the bottom of the ocean, but likewiſe under mountains, continents, &c. in every part of the world hitherto explored. But from what principles they were generated; at what diſtance of time from the creation of the world; or whether nearer to its center, or its ſurface; are all of them problems not eaſily ſolved, while the phenomena of fire remain in ſo much obſcurity: for as M. Macquer juſtly obſerves, in his Elements of Chymiſtry, vol. 1. p. 7, "an accurate diſtinction has "not yet been made between the phenomena of fire ac"tually exiſting as a principle in the compoſition of bo"dies, and thoſe which it exhibits when exiſting ſepa"rately in its natural ſtate: nor have proper and diſ-

"tinct appellations been aſſigned to it under thoſe differ-"ent circumſtances:" therefore neither the time, the "place, nor the mode in which ſubterraneous fire was generated, can be truly aſcertained, till thoſe clouds of darkneſs are removed from the ſcience of chymiſtry.

However, thus much we learn from daily experience: namely, that a certain degree of moiſture and dryneſs are greatly inſtrumental in the production of fire in the vegetable and mineral kingdoms: and alſo that thoſe fires commence from the firſt increment of heat, and gradually increaſe to their full maturity: therefore, if we may be allowed to reaſon from the analogy which one part of nature bears to another; we ſhould thence infer, that ſubterraneous fires were generated from the ſame elementary principles, and in like manner gradually increaſed to maturity.

Having attempted to ſuggeſt ſome idea concerning the original production of ſubterraneous fire, let us return to the chaotic ſtate of the earth, and endeavour to trace its progreſſive operations from the firſt increment of heat, to its full maturity, and mark its effects on the incumbent *ſtrata*.

1. If a certain degree of moiſture and dryneſs were equally as neceſſary to the production of fire in the bowels of the earth, as in mineral and vegetable kingdoms, we might thence infer, that thoſe parts of the

globe which firſt began to conſolidate, were alſo the firſt which began to generate fire: therefore, ſince it appears, Chap. V. that the central part of the earth began to conſolidate before the ſuperficial part thereof, the preſumption is great, that the former became ignited before the latter.

2. We have alſo obſerved, Chap. V. that the chaos began to conſolidate by the union of ſimilar particles; whence it appears that an univerſal ſameneſs prevailed either in the ſame *ſtratum*, or in the central part of the earth: therefore it ſeems highly probable that ſubterraneous fire was generated univerſally alike in the ſame *ſtratum*, or in the central part of the earth, at one and the ſame point of time, and gradually increaſed to its full maturity: as repreſented Plate I. fig. 1. F F and G, *ſtrata* of liquid fire.

3. It is a truth univerſally known, that all bodies expand with heat, and that the force or power of that law is unlimited: therefore, as ſubterraneous fire gradually increaſed, ſo in like manner its expanſive force increaſed until it became equal to the incumbent weight. Gravity and expanſion being then equally balanced, and the latter continuing to increaſe every day more and more, became ſuperior to the incumbent weight, and diſtended the *ſtrata* as a bladder forcibly blown.

4. Now if the fire thus generated was ſurrounded by a ſhell or cruſt, of equal thickneſs, and of equal denſity, its incumbent weight muſt have been equal: on the contrary, if the ſurrounding ſhell or cruſt was unequally thick, or unequally denſe, the incumbent weight muſt have been unequal.

Therefore, ſince it appears, Chap. VI. that the primitive iſlands were uniform protuberances gradually aſcending from the deep, the incumbent weight muſt have been unequal: for as the ſpecific gravity of ſtone, ſand, or mud, is ſuperior to that of water, we may thence infer that the incumbent weight of the former, muſt have been greater than that of the latter. For example:

Let Plate IV. fig. 3. repreſent a ſection of the antediluvian earth; A B C, the primitive iſlands; D D the bottom of the ocean; and F F a *ſtratum* of ſubterraneous fire. Now the incumbent weight at A B C, being greater than at D D; the bottom of the ſea would conſequently aſcend, by the expanſive force of F F, ſooner than the iſlands A B C. The bottom of the ſea being thus elevated, the incumbent water would flow toward the leſs elevated parts to reſtore the equilibrium of its preſſure. Conſequently the iſlands A B C, became more or leſs deluged, as the bottom of the ſea was more or leſs elevated; and this effect muſt have been more or leſs univerſal, as the fire prevailed more or leſs univerſally,

ſally, either in the ſame *ſtratum*, or in the central part of the earth. Therefore, ſince it appears, that ſubterraneous fire operated univerſally in the ſame *ſtratum*, and with the ſame degree of force; it appears much more probable, that the deluge prevailed univerſally over the earth, then partially; and more eſpecially when we conſider the elevation of the antediluvian hills, according to Chap. VI.

But the tragical ſcene does not end with an univerſal flood, and the deſtruction of terreſtrial animals: for the expanſive force of ſubterraneous fire, ſtill increaſing, became ſuperior to the incumbent weight and coheſion of the *ſtrata*, which were then burſt, and opened a communication between the two oceans of melted matter and water.

The two elements coming thus into contact, and the latter becoming inſtantaneouſly converted into ſteam, produce an exploſion infinitely beyond all human conception; for it has already been obſerved, that the expanſive force of water thus converted into ſteam, exceeds that of gunpowder, in the proportion of 14,000 to 500.

The terraqueous globe being thus burſt into millions of fragments, and from a cauſe apparently ſeated nearer to its center than its ſurface, muſt certainly have been thrown into ſtrange heaps of ruins: for the fragments of the *ſtrata* thus blown up, could not poſſibly fall together again into their primitive order and regularity: therefore an infinite number of ſubterraneous caverns muſt have enſued at the diſtance of many miles, or many hundreds of miles below the bottom of the antediluvian ſea.

Now it is eaſy to conceive, when a body of ſuch an immenſe magnitude as the earth, which is nearly 8000 miles in diameter, was thus reduced to a heap of ruins, that its incumbent water would immediately deſcend into the cavernous parts thereof; and by thus approaching ſo much nearer toward the center, than in its antediluvian ſtate, much of the terreſtrial ſurface became naked and expoſed, with all its horrid gulphs, craggy rocks, mountains, and other diſorderly appearances.

Thus the primitive ſtate of the earth ſeems to have been totally metamorphoſed by the firſt convulſion of nature, at the time of the deluge; its *ſtrata* broken, and thrown into every poſſible degree of confuſion and diſorder. Hence, thoſe mighty eminences the Alps, the Andes, the Pyrenean, and all other chains of mountains, were brought from beneath the great deep. Hence, the ſea retired from thoſe vaſt tracts of land, the continents; became fathomleſs and evironed with craggy rocks, cliffs, and impending ſhores, and its bottom ſpread over with mountains and vallies like the land.

It is further to be obſerved, of the horrid effects of this convulſion; namely, that as the primitive iſlands were more ponderous, and leſs elevated, than the bottom of the ſea; may we not thence infer, that the former more immediately ſubſided into the ocean of melted matter, than the latter; and therefore became the bottom of the poſtdiluvian ſea: and the bottom of the antediluvian ſea being more elevated, was converted into the poſtdiluvian mountains, continents, &c. Such were apparently the conſequences ariſing from the firſt convulſion of nature: and this conjecture is remarkably confirmed by the vaſt number of foſſil ſhells, and other marine *exuviæ*, found imbeded near the tops of mountains, and the interior parts of continents, remote from the ſea, in all parts of the world hitherto explored, as repreſented Chap. VII.

The above phenomena have generally been aſcribed to the effects of an univerſal flood; but we preſume ſuch concluſions were too haſtily drawn: for it manifeſtly appears, upon a more ſtrict examination of the various circumſtances accompanying theſe marine bodies; that they were actually generated, lived, and died, in the very beds wherein they are found; and therefore thoſe beds were originally the bottom of the ocean, though in ſome inſtances, they are now elevated ſeveral miles above

its

its level. Thus we find a further agreement between natural phenomena and the laws of nature.

Hence it appears, that mountains and continents were not primary productions of nature; but of a very diſtant period of time from the creation of the world. A time wherein the *ſtrata* had acquired their greateſt degree of coheſion and firmneſs. And a time in which the teſtaceous matter of marine ſhells was become changed to a ſtony ſubſtance. For I have frequently obſerved in the fiſſures of the limeſtone *ſtrata*, fragments of the ſame ſhell adhering to each ſide of the cleft, in the very ſtate in which they were originally broken: inſomuch that if the ſeveral parts were brought together, they would apparently tally with each other, Whence it is evident that a conſiderable ſpace of time had elapſed between the chaotic ſtate of the earth and the deluge; which according to the Moſaic account was upward of 1600 years: but theſe obſervations are rather a digreſſion from the ſubject, and only ſerve to ſhew the agreement between revelation and reaſon: Therefore to return.

It may poſſibly be alledged, that many of the foſſil bodies imbeded near the tops of mountains, are natives of very diſtant regions of the earth; and therefore could not have exiſted in the climates where they are now entombed, according to the preſent conſtitution of nature:

whence it becomes neceſſary to ſhew, that thoſe very climates were originally ſuitable to the nature of their exiſtence; but this ſhall be deferred to the following chapter.

We have indeed already related a ſeries of facts, in Chap. VII. which ſhew that ſuch foſſil bodies were actually generated, and have lived and died in the very beds wherein they are found, and conſequently were not removed from diſtant regions of the earth, to their preſent ſituation, by a flood, or floods of water, as commonly ſuppoſed: therefore let us return to the conſideration of ſundry phenomena relative to ſubterraneous convulſions and the deluge of Noah, and likewiſe to inveſtigate the improbability of a ſecond univerſal flood commencing in any future age.

According to the Moſaic account, the deluge was attended with ſundry phenomena analogous to thoſe which generally accompany ſubterraneous convulſions: whence it is preſumed, that the former and the latter might have ariſen from one and the ſame cauſe.

1ſt. We have already obſerved, that previous to an eruption of Veſuvius, the ſea retires from the adjacent ſhore, till the mountain is burſt open, and begins to diſcharge its fiery contents; then returns with impetuoſity, and overflows its boundary. Such operations of nature ſeem to imply, that mount Veſuvius and the parts adjacent were actually elevated above their natural poſition, previous to the eruption; and ſubſided again to their former level as ſoon as the ſteam found vent. And this conjecture is apparently confirmed by the ſubterraneous exploſions which commonly precede the eruptions: for the ſudden converſion of water into ſteam by melted matter, we have already obſerved, produces the moſt violent effects.

2d. The return of the ſea toward the ſhore, immediately after the mountain is burſt open, evidently ſhews that the mountain, previous to that event, ſubſides to its former level, and therefore the waters return to reſtore the equilibrium of its preſſure. Hence we infer, that the fluctuations of the ſea, which accompany ſubterraneous convulſions, wholly ariſe from that cauſe: for when the land is more elevated by the force of ſteam than the bottom of the ocean, the water retires from the ſhore toward the leſs elevated parts, and leaves its bottom dry: and when the bottom of the ſea is more elevated by the ſame cauſe than the land, the water runs in mountainous waves toward the land, and deluges the ſhores. Which ſeems to have been the cauſe of thoſe dreadful floods at Liſbon and Cadiz, in the year 1755; and alſo that which deſtroyed Callao in the year 1746. This idea ſeems to be confirmed by the ſpace of time elapſed between the convulſion and the arrival of the wave at the above cities, an hour and half after the ſhocks had ceaſed: and their being obſerved at ſome conſiderable diſtance rolling toward the towns, points out in ſome degree the direction and ſituation of the elevated part of the ocean, from whence the floods proceeded.

3d. As many parts of Europe and Africa were affected in the above manner, but in a leſs degree, on the firſt of November 1755; we may thence infer the powerful and extenſive effects of ſubterraneous convulſions.

Having conſidered ſubterraneous fire and water as the principal agents concerned in theſe ſtupendous operations of nature; it becomes requiſite to obſerve, that ſteam is ſuſceptible of a conſiderable degree of condenſation by a ſmall degree of cold: therefore the ſame degree of expanſive force can only exiſt during the ſame degree of heat. Whence it is evident, that the undulations of the ſea and confined waters, can extend no further than ſubterraneous fire extends: conſequently, as the undulations of the ſea and confined waters were obſerved throughout Europe, and many parts of Africa, on the firſt of November 1755, we may thence infer that ſubterraneous fire extended ſo far at leaſt.

It now remains to conſider, in a more particular manner, the cauſe of theſe undulations.

When the *ſtrata* incumbent on the melted matter becomes elevated and burſt open, ſo as to admit of ſea water falling upon the melted matter, a ſudden rarefaction of water into ſteam enſues, which may be productive of a further admiſſion of cold water. Hence ariſe ſudden condenſations and rarefactions of ſteam, and conſequently violent tremours or ſhakings of the earth.

The impending roof being ſeparated from the liquid fire by ſteam thus generated, permits the vapours to extend laterally in all directions from the original ſource; whereby the *ſtrata* becomes progreſſively elevated and the parts raiſed, more ſo than thoſe in the act of ſeparation.

Hence the horizontal poſition of the earth's ſurface becomes altered to that of an inclined plane: conſequently, buildings erected in perpendicular direction, acquire a reclining poſture; and the waters of the ſea, lakes, and ponds, receive an undulatory motion, with as much certainty as that contained in a veſſel ſuddenly elevated on one ſide more than on the other. Water being thus agitated by one impeding force, continues undulating till its acquired momentum is overcome by the reſiſtance of ſome external cauſe.

Such however, are the phenomena, and ſuch the principles from whence we preſume they ariſe: we therefore conſider them as quite analogous to the principles applied in the inveſtigation of the deluge; and as we ſhall have occaſion to enlarge upon this ſubject in a future part of the work, we defer for the preſent adding any more inſtances in favour of the doctrines above advanced.

To what has been ſaid, we may add a few obſervations on ſome peculiar properties inherent in matter, which greatly contribute to produce the above ſuppoſed effects.

The Reverend Mr. Michell, in his excellent Treatiſe on Earthquakes, has ſet theſe qualities in a very conſpicuous light.

" The compreſſibility and elaſticity of the earth," ſays the learned author, " are qualities which do not " ſhew themſelves in any great degree in common in- " ſtances, and therefore are not commonly attended " to. On this account it is, that few people are aware " of the great extent of them, or the effects that may " ariſe from them, where exceeding large quantities of " matter are concerned, and where the compreſſive force " is commonly great.

" The compreſſibility and elaſticity of the earth may " be collected in ſome meaſure from the vibration of " the walls of houſes, occaſioned by the paſſing of car- " riages in the ſtreets next to them. Another inſtance, " to the ſame purpoſe, may be taken from the vibration " of ſteeples, occaſioned by the ringing of bells, or

" guſts of wind: not only ſpires are moved very conſi-
" derably by this means, but even ſtrong towers will
" ſometimes be made to vibrate ſeveral inches, without
" any disjointing of the mortar, or rubbing the ſtones
" againſt one another. Now it is manifeſt, that this
" could not happen without a conſiderable degree of
" compreſſibility and elaſticity in the materials of which
" they are compoſed."

Hence we may infer, that if ſo ſhort a length of ſtone as that of a ſteeple, viſibly bends, by ſo ſmall a degree of force as the ringing of bells, or a blaſt of wind: we may thence conclude, that the *ſtrata*, in their primitive ſtate might become conſiderably diſtended by an unlimited force: ſince it appears by a fair deduction, that if a globe 80 inches diameter, ſuffered a degree of expanſion equal to the thickneſs of a human hair; the ſame proportion, by analogy, would have raiſed the bottom of the ocean one fourth of a mile perpendicular height above its former level, and thereby have occaſioned an univerſal flood; ſince we cannot ſuppoſe, that the elevation of the primitive iſlands were more than forty or fifty feet, compared to thoſe formed in the ſea by the flux and reflux of the water, according to Chap. VI.

Having concluded our obſervations on the deluge, the origin of mountains, continents, and all other irregular appearances, on the ſurface and interior parts of the earth; let us inquire into the improbability of a ſecond univerſal flood, and likewiſe into the cauſe of ſubterraneous convulſions having produced more violent effects in the early ages of the world, than they have done ſince the commencement of records.

It will readily be granted that the *ſtrata* which compoſe the earth, had originally an uniform, concentric arrangement; and likewiſe, that they had acquired their greateſt degree of coheſion and firmneſs before they were burſt and thrown into heaps of confuſion: whence it is evident, that a much greater degree of force was requiſite to overcome the incumbent weight and coheſion of the *ſtrata*, in that firm uniform ſtate, than can be requiſite to ſeparate the fractured parts thereof; conſequently the ſame degree of force can never accumulate in any future age while ſo many fiſſures and volcanos daily give vent to the expanſive vapours, and thereby counteract their violent effects.

Hence it appears, that as the expanſive force of ſubterraneous ſteam in the poſtdiluvian world, is ſo much inferior to that accumulated in the antediluvian ſtate of nature; and the mountains of the former, being ſo much more elevated than the hills of the latter; the preſumption is great, that the earth can never become deluged a ſecond time from a ſimilar cauſe, nor its *ſtrata* ſuffer the ſame degree of violence.

But after all our attempts to inquire into theſe difficult and immenſe operations of nature, the magnitude of the earth ſo much exceeds the bounds of human conception, that we can form no adequate idea of its bulk, nor of the relation which the mountains, and other inequalities, bear to its diameter: therefore let us reduce this great globe to ſuch a ſcale as we can diſtinctly view and comprehend.

It is generally allowed that the earth is nearly 8000 miles diameter: therefore let us meaſure it by a ſcale equal 80 inches: ſince one inch will then bear the ſame proportion to a globe 80 inches diameter, as 100 miles does to the diameter of the earth.

Hence one tenth of an inch bears the ſame proportion to a globe 80 inches diameter, as a mountain 10 miles perpendicular height, does to the earth.

Again, as one-hundredth part of an inch is to a globe 80 inches diameter; ſo is a mountain one mile perpendicular height to the earth.

And as the thickneſs of a human hair, is nearly equal one four-hundredth part of an inch, it will nearly bear the ſame proportion to a globe 80 inches diameter, as a mountain one-fourth of a mile perpendicular height, does to the earth.

These proportions being duly conſidered, we ſhall be enabled thereby to form ſome comparative idea of the relation between the antediluvian hills and the poſtdiluvian mountains: ſome of the latter we know, from geometrical and barometrical menſurations, are upward of three geographical miles, or 19,026 feet above the level of the ſea. See Ulloa's Voyage, vol. 1. p. 442. Whereas we cannot ſuppoſe the former were more than 40 or 50 feet perpendicular height above it, ſince they were formed by the action of the tides as ſand banks are formed in the ocean.

The inequalities on the earth's ſurface, before and after the flood, being thus meaſured by a ſcale familiar to our conception, we may form ſome general idea of the great alterations which this globe has undergone, and alſo of the improbability of a ſecond univerſal flood ever ariſing from a ſimilar cauſe.

In the former part of this work we have pointed out ſome inſtances, wherein the reſult of our reaſoning manifeſtly coincides with revelation; therefore though we have aſſigned a different cauſe for an univerſal flood, than that in the ſcripture account; yet in ſome reſpects the two accounts are ſo perfectly analogous, that I am inclined to conſider the Moſaic account of the flood as judiciouſly accommodated to vulgar minds, rather than to thoſe of men accuſtomed to phyſical inveſtigations, and as ſuch, of more general utility.

In the ſcripture account we are told, that "the "fountains of the great deep were broken up, and the "windows of heaven were opened, and the rain was "upon the earth forty days and forty nights." And in the book of nature we find, that the earth is frequently burſt open and deluges the adjacent countries, together with the deſtruction of ſome thouſands of inhabitants: and alſo that theſe convulſions of nature are accompanied with inceſſant rains. Whence it is preſumed there is a conſiderable analogy between the facts recorded in revelation, and the operations of nature. In ſhort, the analogy is ſo extremely obvious, that we think it needleſs to add any thing more to illuſtrate the ſubject.

Being fully perſuaded that the preceding attempts to inveſtigate an univerſal flood, the origin of mountains, continents, &c. have ſome foundation in nature and truth, I am induced thereby to offer the following hiſtorical accounts to the conſideration of the reader, although they have generally been looked upon as fabulous; preſuming they are attended with ſome natural circumſtances not before conſidered. The accounts are recorded in the Poſthumous Work of the learned Doctor Robert Hooke, p. 439, 441, 443, to the following effect.

1. It is recorded by Fulgoſas, that in the year 1462, as ſome men were working a mine, near Bern in Switzerland, they found an old ſhip 100 fathoms deep in the earth, built as ours are, with anchors of iron and ſails of linen, with the carcaſes of 40 men.

2. Pairre Naxis, relates a like hiſtory of another ſuch ſhip having been found under a very high mountain.

3. In like manner the jeſuit Euſebius Neucombergus, in his ſecond chapter of the fifth book of Natural Hiſtory, ſays, that near the Port of Lima in Peru, as the people were working a gold mine, thoſe who followed the *vein*, found an old ſhip, on which were many characters very different from ours.

4. Strabo alſo relates, in his firſt book, that the wrecks of ſhips have been found at the diſtance of 3000 furlongs, or 375 miles from the ſea. Thus far Dr. Hooke.

5. Dr. Plott, in the eighth chapter of his Natural Hiſtory of Staffordſhire, relates a ſtory ſomewhat ſimilar to the former; namely, that the maſt of a ſhip with a pulley hanging to it, was found in one of the Greenland mountains.

Such are the accounts recorded by ſeveral authors, relative to ſhips having been found in the bowels of the earth remote from the ſea, and which have hitherto appeared highly fabulous: but we hope the following obſervations will free them from the imputation of fable.

Firſt, The accounts do not ſeem to have been invented, either in favour, or in oppoſition, to any particular ſyſtem, but ſimply related from people who were eyewitneſſes of the ſeveral phenomena.

Secondly, Two of the ſhips are expreſsly ſaid to have been found in *mines*, or *mineral veins*.

Hence it is neceſſary to obſerve, that the generality of mineral veins, are no other than fiſſures in the *ſtrata* containing mineral ſubſtances, which in all probability were originally produced by ſubterraneous convulſions at the time of the deluge, when the waters prevailed univerſally over the earth, and when the *ſtrata* were burſt to the depth of many miles, and when the incumbent waters deſcended into the gulfs thereof, and left much of the terreſtrial ſurface naked and expoſed, with all its horrid gulfs, &c.

Now if ſhips were in uſe at the time of that dreadful cataſtrophe, and floating immediately over theſe gulfs at the time they were opened, they muſt neceſſarily have deſcended therein, and have remained in the bowels of the earth, and probably at the diſtance of many hundred miles from the ſea, ſince the bottom of the ſea was converted into mountains and continents. Such effects are not however repugnant to the operations of nature: for we have had ſeveral recent inſtances ſomewhat ſimilar, and particularly at Port-Royal in Jamaica, in the year 1692; at which era, not only many houſes were ſwallowed up, but alſo ſeveral ſhips and ſloops ſuffered the ſame fate, inſomuch that only ſome parts of their maſts appeared above water. See Lowthorp's Abr. Phil. Tranſ. vol. 2. p. 411, 415. May we not thence infer, that the ſame cauſe might have produced ſimilar effects either at the time of the deluge, or in ſubſequent ages, if ſhips were in uſe. And what ſtill renders this conjecture the more probable is, that of ſubterraneous convulſions having produced much more violent effects in the early ages of the world, than they have done within the laſt period of three or four thouſand years.

Theſe matters being duly conſidered, I preſume they will not only free the accounts above related from the imputation of fable, but will alſo induce the reader to admit them as collateral evidence relative to the origin of mountains, continents, &c. and likewiſe as teſtimonies of the great antiquity of naval architecture, navigation, and ſciences in general, as we have already conjectured, Chapter II.

CHAP.

CHAP. XIII.

Of the Temperature of the Air, and Seaſons of the Year, before and after the Flood.

IN the preceding chapter we have endeavoured to prove from a ſeries of undeniable facts, that the antediluvian world was univerſally deluged: likewiſe the improbability of a ſecond univerſal flood ever ariſing from a ſimilar cauſe in any future age: and alſo that mountains and continents were not primary productions of nature, but were raiſed from beneath the deep at the time of the deluge while the waters prevailed over the earth.

Such were apparently the great alterations and changes which the earth underwent at the time of that dreadful convulſion of nature.

Let us therefore inquire what effects might enſue in the temperature of the air and ſeaſons of the year, from the production of mountains and continents at the time of the deluge: for as the primitive iſlands were apparently formed by the action of the tides, as ſand banks are formed in the ſea, we cannot reaſonably eſtimate their elevation at more than 40 or 50 feet perpendicular height: whereas ſome of the poſtdiluvian mountains have been found by actual menſuration not leſs than 19,026. Whence it is preſumed that the conſtitution of the atmoſphere in the poſtdiluvian world, might undergo an equal change with the different inequalities on the ſuperficial parts of the earth, before and after the flood.

The above inquiry happily depends on ſuch phenomena as are commonly known, though not aſcertained with ſo much accuracy as the importance of the ſubject requires: namely, that of thermometrical obſervations on the temperature of the air by ſea and land in all parts of the world. However, ſince mankind are now accommodated with proper inſtruments for that purpoſe, I have no doubt, but that ſuch obſervations will be made in due time, as will give the ſubject a laſting foundation. The following are ſuch as we have been able to collect for the preſent toward obtaining the end propoſed.

1. It is a general obſervation, that the interior parts of continents are ſubject to greater extremes of heat and cold, than the exterior, or the coaſts of the ſea. Firſt, from the continuance of froſt and ſnow, in the former, at a time when it will not lie on or near the coaſt of the latter. Secondly, from the plants and fruits of the earth being burnt up within land, when there is an agreeable verdure on the ſhore.

2. Hence Cornwall, being a peninſula, is leſs ſubject to extremes of heat and cold, and to ſudden tranſitions from one extreme to another, than the central parts of England: "vegetables flouriſh all winter in the former, "which can only be preſerved in the latter by artificial "means; nor have they often any froſt till after Chriſt- "mas, but a temperate air, and an exceeding fine ver- "dure on the ground; their ſpring ſeaſons are indeed "colder, and laſt longer than in the central parts of "England." Dr. Borlace's Nat. Hiſt. of Cornwall.

3. "The temperature of the air in Norway, differs "more than a ſtranger could well imagine in the ſame "parallel of latitude; for on the eaſt ſide of Norway "the winter's cold generally ſets in about the middle of "October, and continues to the middle of April; the "waters are frozen to a thick ice, and the mountains "and vallies are covered with ſnow.

4. "Yet when the winter rages with ſo much ſeve- "rity on the eaſtern ſide of Norway, the lakes and bays "are open on the weſtern ſide, though in the ſame pa- "rallel of latitude; the air, indeed, is miſty and cloudy, "but froſt is ſeldom known to laſt longer than a fort- "night or three weeks.

5. "In the center of Germany, which is 200 leagues "nearer the line, winters are more ſevere than in the "dioceſe of Bergin, where the inhabitants often won-

" der to read in the public papers, of froſt and ſnow in " Poland and Germany, when they have no ſuch wea- " ther there.

6. " The harbours of Amſterdam, Hamburgh, Co- " penhagen and Lubeck, are frozen ten times oftener " than the harbour of Bergin; and when the harbour " of Bergin is frozen, the Seine at Paris is generally in " the ſame condition.

7. " It ſeldom happens that the bays and creeks are " frozen over in Norway, except thoſe that run far up " the country. In the other parts of the weſtern coaſt, " hard winters, or laſting froſts, are ſeldom heard of." Pontopidon's Nat. Hiſt. of Norway.

8. " It is well known to all who ſail northward, as " far as lat. 77°, that the coaſts are frozen up many " leagues, when the open ſea is not ſo; no not even " under the pole."

9. " Some years ſince, a company of merchants at " Amſterdam, who advanced 100 leagues above Nova " Zembla, toward the eaſt, diſcovered a ſea free from " ice, and very convenient for navigation." Lowthorp's Abridg. Phil. Tranſ. vol. iii. p. 611.

10. We are well aſſured, by the teſtimony of Capt. Baffin, that the northern parts of Greenland are leſs incumbered with ice than the ſouthern; and that he found no ice in Baffin's Bay, though in lat. 74; and, as he

advanced ſtill further north, he found the air more ſoft and temperate; very different from what he had felt in Davis' Straits, and on the ſouth of Greenland.

11. And it appears, in the journals of Frederick Martin of Hamburgh, a man of good credit, that when Spitſbergen is doubled three or four degrees, to the north, no more ice is to be ſeen.

12. Capt. Wood likewiſe obſerves, in a paper which he publiſhed before he performed his voyage, that two Dutch ſhips had proceeded northward, as far as latitude 89°, and there found the ſea free from ice, and of an unfathomable depth; as appears by four of their journals, which though ſeparately kept, concur in thoſe circumſtances.

12. Capt. Wood farther adds, that a Dutchman of great veracity had aſſured him, that he had paſſed even under the pole, and found the weather as warm as at Amſterdam.

13. Other navigators have alſo obſerved, that the weather was warm in lat. 88° north, and the ſea perfectly free from ice, and rolling like the Bay of Biſcay. See the Hon. Daines Barrington's Obſervations on the Probability of reaching the North Pole, p. 11.

14. The ſame author, p. 21, mentions another ſhip having ſailed within half a degree of the pole; and many other intereſting accounts of navigators having ad-

vanced to high latitudes: inſomuch that no doubt can remain of the high ſeas under the pole being open, at all times, and fit for navigation, though much incumbered with ice in lower latitudes. The cauſe of theſe phenomena will be conſidered in its due place.

15. The continent of North America, we are told, is ſubject to great extremes of heat and cold, and to ſudden tranſitions from one extreme to another.

16. That in South Carolina, though ſituate almoſt twenty degrees more ſouth than London, froſt is ſometimes very intenſe; at others they have a degree of heat equal to 100° Fahrenheit's ſcale.

17. "At Cape Henry, lat. 36° 30′ north, the temperature of the air and ſeaſons are much governed by "the winds in Virginia, both as to heat and cold, "moiſture and dryneſs, the variations of which are very "remarkable; there being often great and ſudden "changes. The north and north weſt winds are very "nitrous and piercing, cold and clear, or elſe ſtormy; "the ſouth eaſt and ſouth, hazy and ſultry hot. Their "winter is a fine clear air, mild and dry, which renders "it very pleaſant; their froſts are ſhort, but ſometimes "ſo very ſharp, as to freeze the rivers over, though "three miles broad; nay, even the Potomack river, "where it is near nine miles broad." Lowthorp's Abr. Phil. Tranſ. vol. iii. p. 576.

18. We are alſo told, that their lakes and rivers are generally frozen over early in the winter, and remain in the ſame ſtate till late in the ſpring, though ſituate many degrees more ſouth than the Land's-end of England; and that at Quebec the mercury will frequently mark 100° at one time, and 40° or 50° below the freezing point at another.

19. In Maryland the temperature of the air has been truly aſcertained by Fahrenheit's thermometer. The following table ſhews the reſult of four years obſervations, *viz.* 1754, 1755, 1756, 1757. See Philoſ. Tranſ. vol. li. 62. 82. To which is added a comparative view of the climate of London, for the ſame years; ſhewing the greateſt degree of heat and cold in each month. See Gentleman's Mag. for the above years.

The firſt column contains the months; the ſecond, marked H, ſhews the higheſt ſtate of the mercury; L, the loweſt; and V, the variation in each month. For example: London, January 1754, the higheſt ſtate of the mercury was 48°, the loweſt, 25°, the variation 23°; Maryland, 61° the higheſt, 21° the loweſt, and 40° the variation.

Obſervations on the Temperature of the Air at London, and in Maryland.

	LONDON. Lat. 51° 30′												MARYLAND. Lat. 39°											
Mon.	1754			1755			1756			1757			1754			1755			1756			1757		
	H	L	V	H	L	V	H	L	V	H	L	V	H	L	V	H	L	V	H	L	V	H	L	V
Jan.	48	25	23	45	27	18	49	39	10	44	28	16	61	21	40	69	23	46	73	15	58	65	10	55
Feb.	48	25	23	44	31	13	50	32	18	52	31	21	61	10	51	64	14	50	70	27	43	67	8	59
Mar.	46	29	17	51	32	19	54	35	19	54	33	21	71	27	44	79	24	55	-	-	-	65	30	35
Apr.	54	32	22	65	42	23	53	32	21	61	30	31	73	42	31	80	40	40	83	29	54	65	30	35
May	-	-	-	64	45	19	64	37	27	64	45	19	85	45	40	87	47	40	81	48	33	88	48	40
June	-	-	-	77	61	16	70	48	22	67	56	11	87	56	31	90	70	20	86	44	42	80	72	8
July	-	-	-	70	55	15	68	51	17	77	59	18	87	61	26	93	60	33	93	69	24	90	64	26
Aug.	-	-	-	66	52	14	65	-	-	76	54	22	88	62	26	90	61	29	93	68	25	90	67	23
Sept.	64	43	21	67	48	19	64	50	14	61	53	8	80	73	7	93	45	48	92	60	32	88	47	41
Oct.	56	39	17	65	41	24	62	30	32	56	42	14	80	34	46	75	36	39	90	29	61	67	43	24
Nov.	49	27	22	55	28	27	54	31	23	55	38	17	67	23	44	65	20	45	73	27	46	65	33	32
Dec.	-	-	-	50	34	16	51	31	20	51	35	16	60	23	37	71	15	56	63	13	50	68	28	40

By thus comparing the climate of London with that of Maryland, it appears, that the latter is ſubject to much greater extremes of heat and cold than the former.

Although Fahrenheit's thermometer is generally known, it may not be improper to name the relative degrees of heat and cold referred to in the above table. For example: 32° marks the firſt increment of freezing; 48° the temperature of common ſpring water; 68° that of Matlock Bath; 82° Buxton Bath; 96° vital heat; 114° King's Bath, at Bath; 212° the heat of boiling water; and likewiſe, that cold increaſes in the ſame proportion below the freezing point.

As a further teſtimony that the continent of America is not only ſubject to great extremes of heat and cold, but likewiſe to great and ſudden changes from one extreme to another, the following table is inſerted. It contains the obſervations of Mr. William Wales and Mr. Joſeph Dymond on the temperature of the air at Prince of Wales Fort, on the north weſt coaſt of Hudſon's Bay, in lat. 58° 47′ north, in the years 1768 and 1769.

The firſt column contains the year, month, and day. Thoſe N° 1, 2, 3, ſhew the ſtate of the thermometer, in the morning, noon, and evening. The column D, ſhews the variation of temperature each day; and M, the monthly variation.

Thoſe numbers marked thus —, denote the number of degrees below 0. For example: January 3, the number —24, ſignifies that the mercury was 24° below 0, or 56° below the freezing point.

Obſervations on the Temperature of the Air at Prince of Wales Fort.

1768	1	2	3	D	M
Sep. 10	41	41	41	0	32
14	45	41	38	7	
16	37	34		3	
18	38	33		5	
20	45	38		7	
22	60	63	65	5	
24	54	50	46	8	
28	46	46	44	2	
30	47	50	35	15	
Oct. 3	36	34	29	7	24
6	35	34	29	6	
9	35	37	34	3	
12	32	31	33	2	
15	36	31	17	19	
18	33	32	32	1	
21	36	36	27	9	
24	20	21	13	8	
27	28	27	14	14	
30	22	18	20	4	
Nov. 3	32	24	18	14	48
6	5	—10	— 7	15	
9	— 3	3	4	7	
12	15	12	18	6	
15	3	6	— 5	11	
18	— 7	—14	—15	8	
21	10	7	3	7	
24	7	1	— 7	14	
27	—15	—16	—16	1	
30	—10	— 9	4	14	
Dec. 3	— 6	—10	—17	11	65
6	—16	—22	—26	10	
9	— 9	—13	—20	11	
12	—39	—39	—22	17	
15	—22	—27	—15	12	
18	— 8	—10	—16	8	
21	14	17	13	4	
24	17	26	—24	50	
27	11	15	— 6	21	
30	5	—12	—18	23	

1769	1	2	3	D	M
Jan. 3	—24	—16		8	71
6	—29	31	35	64	
9	—19	—21	—30	11	
12	—28	—15	—17	13	
15	—21	—28	—31	10	
18	—32	—36	—30	6	
21	—29	—36	—36	7	
24	—28	—31	—19	12	
27	—20	—31	—34	14	
Feb. 2	— 1	—21	—30	29	52
4	0	—19	—20	20	
6	—16	—23	—24	8	
9	15	12	12	3	
12	— 3	—21	—26	23	
15	3	— 2	—11	14	
18	— 4	—19	—18	15	
21	6	—20	—32	38	
24	—10	—29	—37	27	
28	— 9	—12	—30	21	
Mar. 3	—13	—15	—30	17	81
6	—19	—30	—41	22	
9	—11	—11	6	17	
12	0	— 5	—23	23	
15	—16	—21	—25	9	
18	1	1	7	6	
21	4	— 8	—11	15	
24	— 5	—21	—23	18	
27	40	24	11	29	
30	20	7	8	13	
Apr. 3	7	— 7	—12	19	68
6	20	— 2	0	22	
9	33	22	11	22	
12	19	15	12	7	
15	29	9	5	24	
18	34	26	20	14	
21	38	17	20	21	
24	36	26	26	10	
27	48	34	34	22	
30	36	32	32	7	

1769	1	2	3	D	M
May 3	45	32	37	13	32
6	50	35	39	15	
9	49	45	26	23	
12	23	24	22	2	
15	40	27	32	13	
18	54	32	44	22	
21	48	40	36	12	
24	43	47	33	14	
27	48	36	34	14	
30	49	34	37	15	
June 3	60	42		18	28
6	45	36	38	9	
9	50	44	40	10	
12	41	39	40	2	
15	46	41		5	
18	50	44	35	15	
21	63	57	41	22	
24	49	57	61	12	
27	60	50	55	10	
30	60	49	44	16	
July 3	76	60	74	6	39
6	54	46	49	8	
9	51	50	61	11	
12	85	48	52	37	
15	55	50	49	6	
18	66	62	52	14	
21	58	62	54	8	
24	64	59	56	8	
27	59	63		6	
30	65	65	54	11	
Aug. 3	50	54	48	6	24
6	68	54	52	16	
9	60	52	58	8	
12	61	53	52	9	
15	56	57	48	9	
18	40	43	44	4	
21	57	51		6	
24	51	48		3	
27	53	49	44	9	
30					

The preceding obſervations evidently ſhew that the continent of North America is ſubject to much greater extremes of heat and cold than England; and likewiſe to more ſudden tranſitions from one extreme to another: therefore, let us endeavour to compare the temperature of the air in Great Britain with that upon iſlands of leſs magnitude, and thoſe with the temperature of the air at ſea.

1. It is well known, that in the ſouth weſt parts of Ireland, myrtles grow in common with other ſhrubs, and that they even arrive to the amazing height of ten or twelve feet; though in moſt parts of England they are only preſerved by art, and perhaps, in no part of it, flouriſh with the ſame degree of luxuriancy: whence it appears, that the climate of Ireland is more temperate that that of England.

2. The Orkneys, we are told, are more ſubject to rain than ſnow or froſt, which do not continue ſo long as in other parts of Scotland.

3. In Farro Iſland, lat. 62° north, froſt ſeldom continues longer than a month, and is withal ſo moderate, that ice is never ſeen in an open bay; nor are ſheep or oxen ever brought under cover.

4. Madeira, ſituate lat. 32° north, is not ſubject to greater degrees of heat than England.

5. In Goree, lat. 15° north, they breathe a cool and temperate air, almoſt the whole year round, being continually refreſhed by land and ſea breezes. See Adenſon's Voyage, p. 104.

6. St. Helena, ſituate lat. 16° ſouth, is alſo extremely temperate, as appears by the obſervations of the Rev. Dr. Maſkelyne, aſtronomer royal, made in the year 1761. See Philoſ. Tranſact. p. 440.

Obſervations on the Temperature of the Air at ST. HELENA, 1761.

April 25	73°	May 1	72°
26	73	2	72
27	73	3	71
28	73	4	71
29	73	5	70
30	72	6	70
		7	72
		8	72

7. And according to the obſervations of our late navigators, moſt of the iſlands in the ſouthern hemiſphere, enjoy a degree of temperature and fertility much ſuperior to the climate of England.

Though it appears from various circumſtances, that iſlands of leſs magnitude than Great Britain are leſs ſubject to extremes of heat and cold; yet the phenomena of land and ſea breezes, which generally accompany thoſe within or near the tropics, ſeem to ſhew that they are ſubject to greater tranſitions from heat to cold, than the atmoſphere at ſea: therefore, ſince the temperature of the air on iſlands has not been generally aſcertained, it becomes neceſſary to inveſtigate the cauſe of thoſe alternate breezes from ſea and land, as the only teſtimony to prove that the temperature of the former is more equable than that of the latter. The phenomena are as follows:

In the middle, or hotteſt part of the day, the ſea breeze blows toward the land, in every poſſible direction: and in the middle, or coldeſt part of the night, the land breeze blows toward the ſea, in every poſſible direction. Thus they alternately ſucceed each other, as conſtantly as night and day.

Theſe ſingular phenomena ſeem to ariſe from the following unalterable laws of nature: namely, thoſe properties of the air whereby it becomes ſubject to rarefaction by heat, and condenſation by cold; and in part to the ſituation of the iſlands within the torrid zone, where days and nights are nearly equal at all times of the year.

To the above, we may add the following qualities of matter. viz. That water is a conductor of heat or cold:

and that the earth is a much inferior conducting ſubſtance. Hence heat and cold do not accumulate on the ſurface of water, but in a ſhort time its whole maſs becomes equally hot or equally cold: and the earth being a non conducting ſubſtance, heat or cold accumulates upon its ſurface, and does not become diffuſed to any conſiderable depth.

Hence it comes to paſs, that the ſurface of land under the torrid zone, acquires much more heat than the ſurface of the ſea: conſequently the atmoſphere of the former becomes more rarefied than that of the latter, and rendered thereby ſpecifically lighter than the air at ſea. The equilibrium of preſſure being thus deſtroyed, the air upon the iſland aſcends by the ſuperior weight of the air at ſea, which moves in all directions toward the central parts of the iſland, and with more or leſs velocity according to the different denſities of the two mediums, and thus produces a ſea breeze. When night approaches, the ſun's heat abates, until the atmoſphere at land becomes equally denſe with that at ſea. The equilibrium of preſſure being thus reſtored, the ſea breeze totally ceaſes and remains quieſcent; till cold, increaſing by the abſence of the ſun, accumulates on the ſurface of the iſlands, and condenſes their incumbent atmoſpheres more than that at ſea: for water being a conductor, cold becomes equally diffuſed throughout its whole maſs;

and therefore cannot accumulate on its ſurface. The land atmoſphere being thus rendered ſpecifically heavier than the air at ſea, begins to deſcend by its ſuperior weight, and then blows in all directions toward the ſea; till the ſun returns, and reſtores the two atmoſpheres to an equal denſity: the air then becomes ſtagnant, and remains in a quieſcent ſtate, till it is again rarefied by the accumulation of heat, as before.

That the ſea has a property of conducting or diffuſing heat and cold throughout its whole maſs, plainly appears from the experiments made on its temperature by Mr. William Bayley, on board his majeſty's ſloop Adventure, in her voyage toward the ſouth. The reſult was as follows:

1772, Aug. 27.	External air - -	72½
	The ſea near its ſurface -	70
	At the depth of 80 fathoms	68
Dec. 27.	External air - -	31½
	The ſea near its ſurface -	32
	At the depth of 160 fathoms	33½
1773, Aug. 28.	External air - -	64
	The ſea near its ſurface -	59
	At the depth of 140 fathoms	56½

That land is not a conductor of heat and cold appears from the uniform temperature of ſprings near the ſurface of the earth: for water contained in wells not more than ten or twenty yards deep, varies nothing in its temperature, winter nor ſummer; being conſtantly about 48 or 50 degrees.

Hence it appears that land and ſea breezes wholly ariſe from an alternate rarefaction and condenſation of the air on iſlands; and to a more conſtant uniform temperature of the air at ſea, both night and day.

Such are the apparent cauſes of the land and ſea breezes, which accompany all the iſlands ſituate within the torrid zone. Therefore the temperature of the air at ſea, is more conſtant and uniform than upon iſlands.

This concluſion is abundantly confirmed by the following table, which contains the obſervations of Mr. Bayley on the temperature of the air at ſea, in his voyage juſt mentioned.

The firſt column contains the year, month, and day. The ſecond ſhews the latitude. The columns 1, 2, 3, ſhew the ſtate of the thermometer, in the morning, noon, and evening; and D, the variation of temperature each day.

Obſervations on the Temperature of the Air at Sea.

1772	Lat. N.	1	2	3	D
July 17	46 26	67	68	66	2
18	46 46	68	69	65	4
19	45 20	65	64	65	1
20	43 56	65	67	64	3
22	43 37	65	66	65	1
24	40 3	66	67	67	1
26	35 31	70	72	69	3
28	32 48	72	74	73	2
	Madeira.				
30	- - -	73	76	74	3
31	32 33	74	75	74	1
Aug. 3	29 43	72	73	72	1
6	26 6	73	73	72	1
9	0 28	74	75	74	1
12	15 7	77	79	78	2
15	13 48	79	81	79	2
18	11 25	77	81	77	4
21	8 41	79	78	77	2
24	6 24	79	79	78	1
27	4 13	78	78	78	0
30	2 40	78	78	77	1
31	2 40	78	78	78	0
Sept. 3	1 1	77	77	77	0
6	0 36	77	77	76	1
	Latitude South.				
9	0 59	75	76	75	1
12	4 10	7	75	72	3
15	8 10	72	75	72	3
18	12 26	72	74	73	2
21	17 9	73	73	72	1
24	21 30	72	72	71	1
27	24 40	70	72	70	2
30	26 58	69	70	71	2
Oct. 3	28 4	66	66	64	2
6	29 42	59	61	58	3
9	33 52	59	59	57	2
12	34 49	57	65	58	8
15	35 33	58	63	57	6
18	34 33	53	57	53	4
21	35 31	57	59	55	4
24	36 39	54	57	57	3
27	33 47	57	61	60	4
30	33 55	56			
	Cape of Good Hope.				

1772	Lat. S.	1	2	3	D
Nov. 20	- - -	-	-	-	-
21	- - -	-	-	-	-
22	33 55	-	60	-	-
23	34 34	-	65	-	-
24	35 20	-	63	-	-
25	37 14	-	63	62	1
26	39 0	62	69	60	9
27	40 1	51	52	53	2
28	40 55	53	59	52	7
29	42 8	52	52	53	1
30	42 26	52	55	52	3
Dec. 3	44 27	47	48	46	2
6	48 23	36	36	35	1
9	49 46	33	34	35	2
12		32	34	32	2
15	55 2	28	31	30	3
18	54 59	31	31	30	1
21	54 7	32	34	31	3
24	56 29	32	34	32	2
27	58 21	32	35	32	3
30	59 22	32	34	32	2
31	59 55	30	33	32	3
1773					
Jan. 3	59 23	31	32	31	1
6	59 59	33	33	33	0
9	61 36	32	35	33	3
12	64 14	33	35	32	3
15	63 35	34	37	33	4
18	65 58	33	34	33	1
21	62 45	33	33	34	1
24	58 24	34	35	33	2
27	56 30	33	35	33	2
30	51 31	39	30	39	1
Feb. 3	49 15	44	44	43	1
6	48 53	42	45	43	3
9	50 17	43	43	41	2
12	50 41	38	40	37	3
15	52 13	37	38	39	2
18	52 52	37	40	37	3
21	52 15	40	41	38	3
24	52 7	40	43	41	3
26	51 18	43	44	44	1
27	50 47	45	43	45	2
28	50 24	43	43	44	1

1773	Lat. S.	1	2	3	D
Mar. 3	46 18	53	53	52	1
6	43 57	53	52	51	2
9	43 46	55	57	54	3
	Adventure Bay.				
12		57	58	52	6
15	43 20	56	56	51	5
18	40 22	53	54	52	2
21	39 16	58	59	57	2
24	38 58	57	51	53	5
27	40 14	61	61	60	1
30	41 14	62	62	64	2
Apr. 3	40 40	62	63	60	3
6	41 4	63	61	57	6
	Q. Charlotte's Sound.				
9	- - -	54	61	55	7
12	- - -	54	62	56	8
15	- - -	52	57	54	5
18	- - -	-	-	-	-
21	- - -	53	59	59	6
24	- - -	49	54	50	5
27	- - -	44	57	54	13
30	- - -	50	54	51	4
May 1	- - -	56	59	54	5
3	- - -	47	57	45	12
6	- - -	48	54	55	7
9	- - -	57	58	54	4
12	- - -	54	52	49	5
15	- - -	47	58	57	11
18	- - -	52	58	47	11
21	- - -	54	57	44	13
24	- - -	49	54	49	5
27	- - -	47	57	49	10
30	- - -	59	59	52	7
June 1	- - -	56	56	50	6
3	- - -	53	58	51	7
6	- - -	52	56	47	9
9	42 50	55	52	48	7
12	45 45	51	54	47	7
15	46 45	54	49	47	7
18	45 50	49	49	47	2
21	44 17	50	51	50	1
24	43 42	47	52	49	5
27	42 23	52	53	51	2
30	43	51	52	50	2

The obſervations contained in the above, and the former tables page 143, 145, 147, together with thoſe related in various other parts of the ſame chapter evidently ſhew,

Firſt, That the climate of North America is more ſubject to extremes of heat and cold, and to more ſudden tranſitions from one extreme to another, than the climate of Great Britain.

Secondly, That the temperature of the air upon iſlands is likewiſe ſubject to greater viciſſitudes than the air at ſea: inſomuch that if the earth was again univerſally covered with water, as in its primitive ſtate, neither froſt nor ſnow, nor a degree of cold equal to that of freezing, could have any exiſtence in the natural world: for it evidently appears that the burning heats of the torrid zone, and the intenſe cold of the frigid zones, do not altogether ariſe from their different ſituations on the globe, with reſpect to the line, but principally from thoſe vaſt tracts of land the continents: for it ſeems to be an undoubted truth, that the high ſeas have at all times been found open and rolling like the Bay of Biſcay; which ſeems to imply, that the regions of the north pole are not occupied either by ice or land; and as a corroborating teſtimony, it has been obſerved that a north wind invariably produces a thaw at the North Cape and Spitzbergen, and a ſouth wind as invariably produces froſt.

On the contrary, the quantity of ice in the ſouthern hemiſphere obſerved by the memorable navigator Capt. Cook, ſeems to imply the exiſtence of land in the regions of the ſouth pole.

Hence it appears that extremes of heat and cold are conſequences wholly ariſing from mountains, and thoſe vaſt tracts of land the continents.

Therefore, ſince mountains and continents were not primary productions of nature, but of a very diſtant period of time from the creation of the world, namely, at the time of the deluge; may we not thence reaſonably infer, that the inclemencies of the ſeaſons were totally unknown in the antediluvian ſtate of nature.

Conſequently, during that particular period of time, from the creation to the deluge; its ſeveral regions were univerſally adapted to the various ſpecies of the animal and vegetable kingdoms: it is therefore reaſonable to ſuppoſe they were inhabited by a much greater variety of ſpecies than could poſſibly exiſt according to the preſent conſtitution of nature, ſince the primitive iſlands were only ſmall protuberances raiſed by the flux and reflux of the tides, as ſand banks are formed in the ſea, and were of little extent or elevation, compared to the mountains and continents in the poſtdiluvian world.

Theſe circumſtances being duly conſidered, ſeem to unfold thoſe wonderful phenomena, which have ſo much perplexed the inquiſitive naturaliſt: namely, the remains of marine and terreſtrial animals, which are found imbeded not only in various parts of this kingdom, but in other parts of the world remote from their native climates. Inſtances of ſuch phenomena are innumerable, and have uſually been aſcribed to an univerſal flood, but I preſume it evidently appears, Chap. VII. that the marine *exuviæ* were actually generated, and have lived and died in the very beds wherein they are found: and likewiſe that thoſe very beds were originally the bottom of the ſea.

The various phenomena of nature thus coinciding with phyſical reaſoning, even down from the creation of the world to the preſent time, leave little room to doubt but that the reſult thereof has ſome foundation in nature, and that all the matters contained therein are parts of one great whole. However that may be in reality, I have the pleaſure to think that the facts are fairly ſtated, and that I have no other object in view than the inveſtigation of truth.

Now ſince it appears that the antediluvian world was univerſally inhabited by all the various ſpecies of the animal creation, previous to the commencement of mountains

tains and continents, the following conſequences would neceſſarily enſue.

Firſt, Thoſe animals and vegetables, whoſe conſtitutions were not formed to withſtand the various inclemencies of the ſeaſons, would conſequently periſh.

Secondly, Thoſe which ſurvived and enjoyed the change of temperature, became the native animals or plants of thoſe climates which they found ſuitable to the nature of their exiſtence.

Such I preſume were the conſequences ariſing from the great change in the conſtitution of nature, which only commenced at the time of the deluge.

Some inſtances ſimilar to the above, with reſpect to the effects of change of climate, happened on the weſtern coaſt of England in the year 1739: namely, the adjacent ſeas previous to that era were plentifully ſtored with ſcollop ſhell fiſh: but ſuch was the ſeverity of that intenſe froſt, that they were almoſt all deſtroyed. Whence it is evident that thoſe animals could not exiſt in cold climates.

As the ſubject before us is of ſome importance, I preſume the following queſtion may ariſe: namely, How comes it to paſs that the high ſeas are open, when thoſe in lower latitudes are frozen up? To which I anſwer, That the ſeverity of the latter is wholly owing to the near approach of the two continents; and that the former may be aſcribed to an extenſive fathomleſs ſea.

To ſuch like cauſes we may aſcribe the deſtruction of various ſpecies of animals and vegetables, in different regions of the earth, ſubſequent to the grand convulſion.

The preceding circumſtances ſeem to imply, that the *exuviæ* of marine animals found remote from their native climates, are ſo many inconteſtible evidences of the alterations produced on the ſuperficial parts of the earth at the time of the deluge; and not as teſtimonies of the deluge itſelf: for, it cannot be ſuppoſed that a bed of oyſters, &c. could have been removed two or three thouſand miles from their native climates, in the ſpace of two or three months, and with ſo much order, as to form ſelect beds of oyſters, cockles, &c. as living fiſh do in the ocean.

Other inſtances might be given to ſhew the improbability of ſuch effects being produced; but we preſume, the above may ſuffice to explode the idea of their having been brought from diſtant regions by a flood or floods of water; and alſo to convince us, that the alterations produced in the conſtitution of the climates, and the deluge itſelf, were undoubtedly effects of the ſame cauſe, and commenced at one and the ſame time, as repreſented Chap. XII.

As the ſubject immediately under conſideration ſeems to be a very intereſting branch of natural hiſtory, I hope it will merit a particular attention from my learned readers: conceiving it may throw ſome light upon the learning and philoſophy of the ancients, with reſpect to the temperature and fertility of the firſt ages, as repreſented by Homer, Heſiod, Ovid, and others.

Before we conclude this chapter, it may not be improper to recite ſome inſtances of animal remains being found remote from their native climates, as a corroborating teſtimony of the preceding concluſions.

A Catalogue *of* Extraneous Fossils, *ſhewing where they were dug up*; *alſo their native Climates. Moſtly ſelected from the curious Cabinet of the late Mr.* Neilson, *in* King ſtreet, Red Lion ſquare.

Their Names, and Places where found.	Native Climates.
Chambered Nautilus. Sheppy Iſland, Richmond in Surrey, Sherborne in Dorſetſhire - - - -	*Chineſe Ocean and other Parts of that great Sea.*
Teeth *of* Sharks. Sheppy Iſland, Oxfordſhire, Middleſex, Surrey, Northamptonſhire - - -	*Eaſt and Weſt Indies.*

Sea Tortoise, ſeveral kinds; the *Hawkſbill*, *Loggerhead*, and *green* Species. Sheppy Iſland -	*Weſt Indies.*
Mangrove Tree Oysters. Sheppy Iſland - - - -	*Weſt Indies.*
Coxcomb Tree Oysters. Oxfordſhire, Glouceſterſhire, Dorſetſhire, and Hanover - - - -	*Coaſt of Guinea.*
Vertebræ *and* Palates *of the* Orbes. Sheppy Iſland, and many other parts of England - - -	*Eaſt and Weſt Indies.*
Crocodile. Germany, Derbyſhire, Nottinghamſhire, Oxfordſhire, and Yorkſhire	*Africa.*
Alligator's Teeth. Oxfordſhire, Sheppy Iſland - - -	*Eaſt and Weſt Indies.*
The Banded Buccinum. Oxfordſhire, and the Alps - - -	*Weſt Indies.*
The Dipping Snail, and Star Fish. Sheppy Iſland - - -	*Weſt Indies.*
Tail Buccinum. Sheppy Iſland, Hordel Cliff in Hampſhire - -	*Eaſt Indies.*
Bamboo, Derbyſhire - - -	*Eaſt Indies.*
Asteria, Stanton in Nottinghamſhire	*Barbadoes.*

The remains of marine animals thus apparently removed from their native climates are innumerable: therefore let the above inſtances be admitted as ſufficient teſtimony of the truth thereof.

The preceding catalogue of animal *exuviæ* is principally ſelected from the marine creation, as they live in a more perfect ſtate of freedom than the terreſtrial animals; and therefore we may ſuppoſe, they would naturally inhabit the climates moſt agreeable to the nature of their exiſtence.

Now ſince it appears, that the *exuviæ* of marine animals are found remote from their native climates, and accompanied with a variety of circumſtances, ſhewing that they were actually generated in the climates where they are found; it appears highly probable that thoſe climates were originally ſuitable to the nature of their exiſtence. It is therefore evident that the antediluvian world was more univerſally inhabited, than the poſtdiluvian ſtate of nature.

Conſidering the great diverſity of ſeaſons before and after the flood, let us inquire into their different effects on the period of human life.

CHAP.

CHAP. XIV.

Of the Period of Human Life, before and after the Flood.

ACcording to Chap. XII, mountains and continents were not primary productions of nature, but that of a very diſtant period of time from the creation of the world: namely, a time wherein the limeſtone *ſtrata* had acquired their greateſt degree of coheſion and firmneſs: and a time too wherein the teſtaceous matter of marine ſhells was become changed to a ſtony ſubſtance: which circumſtances indicate a conſiderable period of time elapſed from the creation to the deluge.

And according to Chap. XIII, mountains and continents were productive of very conſiderable alterations in the temperature of the air and ſeaſons of the year: for it evidently appears that they put a final period to that univerſal temperature which prevailed over the antediluvian world, and occaſioned one perpetual ſpring and harveſt; for the burning heat of the torrid zone, and the intenſe cold in the frigid zones commencing with mountains and continents, divided the year into four ſeaſons, namely, ſummer and winter, ſpring and autumn.

Such were the great changes wrought on the conſtitution of nature, at the time of the deluge: therefore let us inquire what effects theſe great alterations on the atmoſphere produced on the period of human life.

1. It is a truth commonly known, that temperate climates are more friendly to animal or vegetable life, than thoſe ſubject to great and ſudden changes from extreme of heat and cold to another.

2. Invalids are commonly ſent from their native to a more temperate climate to recruit their conſtitutions, and ſeldom fail of being benefitted thereby. May we not thence infer, that if a temperate air proves inſtrumental in reſtoring a weakly conſtitution, that it may likewiſe contribute to prolong the life of a healthy one.

3. To the ſame purpoſe the Rev. Dr. Burnet obſerves in his Sacred Theory, vol. 1. p. 275, 276. "I know "no place, where people live longer than in the little "Iſland of Bermudas. According to the proportion "of time they hold out there, after they arrive from "other parts of the world, one may reaſonably ſuppoſe "that the natives would live two hundred years; and "yet nothing appears in that iſland that ſhould give "long life above other places, but the extraordinary "ſteadineſs of the weather, and temperature of the air "throughout the whole year, ſo that there is ſcarce any "difference of ſeaſons."

4. Lord Bacon likewiſe remarks, in his Hiſtory on Life and Death, that "iſlanders are, for the moſt part, "longer lived than thoſe that live on continents: for "they live not ſo long in Ruſſia as in the Orcades; nor "ſo long in Africa, though in the ſame parallel of latitude, as in the Canaries and Terceras, and the Japonians are longer lived than the Chineſe, though the "Chineſe are made for long life. And this is no wonder, ſeeing the air of the ſea doth heat and cheriſh in "cooler regions, and cool in hotter.

5. "The countries which have been obſerved to produce long livers are theſe, Arcadia, Etolia, India "on this ſide the Ganges, Braſil, Taprobane, Britain, "Ireland, with the iſlands of the Orcades and Hebrides."

6. Italy is generally conſidered as a more temperate climate than that of England, and productive of greater longevity; though we have many long-lived people in Britain. The above noble author recites the following inſtances of great longevity in the former, viz.

"The year of our Lord ſeventy-ſix, the reign of "Veſpaſian, is memorable; for in that year there was "a taxing. Now taxing is the moſt authentic method "of knowing the age of men. In that part of Italy, "lying between the Apennine mountains and the river "Po, there was found a hundred and twenty-four

“ perſons that either equalled, or exceeded, a hundred
“ years of age: namely,

Fifty-four - - 100 years each.
Fifty-ſeven - - 110
Two - - - 125
Four - - - 130
Four - - - 135 or 137
Three - - - 140

“ Beſide the above, Parma contained five; whereof,

Three were - - 120 years each.
Two - - - 130
One in Bruxells - 125
One in Placentia - 131
One in Faventia - 132

“ A town near Placentia, ten; whereof,

Six were - - 110 years each.
Four - - - 120
One in Rimino - 150, whoſe name was Marcus Aponius.”

His Lordſhip alſo enumerates many inſtances of much greater longevity than the above, but does not conſider the records of them equally authentic with the former.

The following table contains many remarkable inſtances of longevity in Great Britain and Ireland, in the preſent age; but we preſume, they cannot boaſt of a number equal to the above, living at one and the ſame time.

A TABLE OF LONGEVITY.

Names of the People.	Age.	Places of Abode.	Living or dead
Thomas Parre	152	Shropſhire	Nov. 16, 1635
Henry Jenkins	169	Yorkſhire	Dec. 8, 1670
Robert Montgomery	126	ditto	Living in the year 1670
Anonymous	140	ditto	Both living 1664
His Son	100	ditto	
The Counteſs of Deſmond	140	Ireland	
Mr. Ecleſton	143	ditto	1691
J. Sagar	112	Lancaſhire	1668
—— Lawrence	140	Scotland	
Simon Sack	141	Trionia	May 30, 1764
Col. Thomas Winſloe	146	Ireland	Auguſt 22, 1766
Francis Conſiſt	150	Yorkſhire	January 1768
Chriſtian Jacob Drakenberg	146	Norway	June 24, 1770
Margaret Forſter	136	Cumberland	Living 1771
Her Daughter	104	ditto	
Francis Bons	121	France	Feb. 6, 1769
John Brookey	134	Devonſhire	Living 1777
James Bowels	152	Kilinworth	Auguſt 15, 1656
William Mead, M. D.	148	Ware	October 28, 1652
John Tice	125	Worceſterſhire	March 1774
John Mount	136	Scotland	February 27, 1776
A goldſmith	140	France	June 1776
Mary Yates	128	Shropſhire	—— 1776
William Bren	121	Brunſton	
Jeremiah Gilbert	132	Apthorp	
John Bayles	126	Northampton	April 5, 1706
Martha Waterhouſe	140	Bieſley Yorkſh.	
Heſter Jagar her Siſter	107		
A woman	154	Cornwall	
John Campbell	112	Dungannon Ir.	Living 1783
William Ellis	130	Liverpool	Auguſt 16, 1780
Dumiter Radaly	140	Harmenſtead	January 16, 1782
Val. Catby	116	Preſton, Hull	October 1782
William Evans	145	Carnarvan	Living 1782
James Southwell	116	Limerick	
Lewis Jones	113	North Wales	1784
Hugh Rowland Hughes	114	ditto	1784

The above table of longevity was moſtly ſelected from the public papers, by a gentleman whoſe veracity may be relied on, though the authorities are omitted.

To the above we may add, that the natives of North America are ſhorter lived than thoſe of Great Britain and Ireland; and likewiſe that a Britiſh conſtitution will laſt longer in America than a native one. This information I received from the beſt authority.

The foregoing obſervations evidently ſhew that temperate climates prolong the period of human life in the poſtdiluvian ſtate of nature; and therefore it ſeems reaſonable to infer, that the ſame cauſe might have produced the ſame effect in the antediluvian world: ſince it appears according to the preceding chapter, that a more univerſal temperature prevailed over the different regions of the earth before the flood, than ſubſequent to it.

Whence we may infer, that the longevity of the antediluvians muſt have been greatly ſuperior to that of the poſtdiluvian race of men. And this conjecture is rendered much more probable when we conſider that our firſt parents were created with conſtitutions perfectly free from all thoſe taints and impurities, acquired by intemperance in after ages; and that they were alſo provided with food the moſt ſuitable to the nature of their exiſtence.

Therefore, if ſo many of the poſtdiluvians have ſurvived the age of a hundred and twenty, or a hundred and thirty, under all the diſadvantages of conſtitution, climate, &c. the preſumption is great, that the antediluvians might have lived to the age of many hundred years according to the ſcripture account.

Other circumſtances apparently concurred to prolong the lives of the antediluvians: namely, according to Chap. VI. the primitive iſlands were of no conſiderable extent or elevation compared to the mountains and continents in the poſtdiluvian world: and therefore according to Chap. XIII. the temperature of the air and ſeaſons in the antediluvian world, and the ſucculent ſtate of the earth's ſurface, ſeem to have rendered the vegetable productions extremely luxuriant at all times of the year, inſomuch as to ſupply the calls of human nature without the leaſt art or labour.

Hence no anxious thoughts or jealouſies invaded their repoſe; property and dominion being then unknown, men paſſed away their time in ſweet repoſe on the ever verdant turf.

Therefore, ſince harmony thus prevailed univerſally both in the moral and the natural world, we may therefore conclude that ſo many concomitant cauſes co-operating toward one and the ſame end, might probably ſtretch out the period of human life much beyond the reach of our conceptions; nay even to that of near one thouſand years, as recorded in the ſcripture accounts.

Such appear to have been the conſequences ariſing from the preceding cauſes: but alas! the moſt permanent ſtate of human felicity is liable to invaſion from natural cauſes, and particularly in the inſtance immediately under conſideration: for according to Chap. XII. the primitive iſlands were not only deluged by means of that horrid convulſion, but the whole fabric of the earth was burſt into millions of fragments, and thrown into the greateſt heaps of confuſion; and thoſe inequalities deſtroyed that univerſal temperature and fertility of the earth, which prevailed in the antediluvian world.

The earth now became ſubject to the burning heats of ſummer, and the ſeverities of winter; mankind were alſo reduced to the neceſſity of ſowing, reaping, and of laying up a winters ſtore; for the great changes wrought in the conſtitution of the atmoſphere, put a final period to the ſpontaneous productions of the earth: therefore, he who ſowed would expect to reap the fruits of his own labours; and he who contrived the means of protecting himſelf from the inclemencies of the ſeaſons, would naturally expect to enjoy an excluſive right to the works of his own hands. Hence commenced property, which previous to that convulſion, had no exiſtence among mankind.

Neceſſity therefore may be conſidered as the parent of property, and the conſequences ariſing from property are, creating a thouſand unnatural wants, which its poſſeſſors ſtudiouſly endeavour to gratify; and their example creates ſimilar ideas in thoſe who have it not, but who nevertheleſs attempt to ſatisfy their imaginary wants by unnatural means.

Hence the neceſſity of law, dominion, and ſubordination, which before that epoch were unneceſſary and unknown: for the calls of human nature being ſo bountifully provided, rendered all government, law, or diviſion of property uſeleſs: for in ſuch a ſtate there could be no temptation to diſhoneſty, fraud, injuſtice, or violence; nor indeed any deſires which might not be gratified with innocence.

Hence that proneneſs to vice, which civilized nations have thought to be natural, cannot poſſibly exiſt in a ſtate of nature like this, where every one equally partakes the bleſſings of life, which the author of nature has thus amply provided for him.

All theſe circumſtances being duly conſidered, ſeem to imply that the period of human life began to contract gradually from that particular era, to its preſent ſtandard: for ſince a conſtitution removed from a temperate, to an intemperate climate, will laſt longer than a native conſtitution; by parity of reaſon we may infer, that the antediluvians would live much longer in the poſtdiluvian world than thoſe born after the flood.

Having conſidered the conſequences ariſing from the great revolutions in the natural world, on the period of human life, let us take a view of the ancient records, and obſerve their agreement with the reſult of the preceding inquiries.

LONGEVITY before the FLOOD.		LONGEVITY after the FLOOD.			
	Years.		Years.		Years.
Adam	930	Noah after the Flood	350	Reuben	124
Seth	912	Shem after the Flood	502	Simeon	120
Enos	905	Arphaxad	438	Levi	137
Cainan	910	Salah	433	Judah	119
Mahalaleel	895	Eber	464	Dan	124
Jared	962	Peleg	239	Naphtali	130
Methuſelah	969	Reu	239	Gad	125
Lamech	777	Serug	230	Aſher	126
Noah before the Flood	600	Nahor	148	Iſſachar	122
Shem before the Flood	98	Terah	205	Zebulun	114
		Abraham	175	Joſeph	110
		Iſaac	180	Sarah	127
		Jacob	147	Kohath	133

According to the ſcripture account, Adam lived to the age of nine hundred and thirty, and Noah to the age of nine hundred and fifty.

Hence it appears, that the period of human life was not contracted during that period of time: we may thence infer, that the temperature of the air and ſeaſons ſuffered no alteration before the flood. Theſe circumſtances perfectly coincide with the reſult of former reaſonings, relative to temperate climates prolonging the period of human life.

And it is alſo evident from the ſame authority, that the period of human life became gradually contracted from the flood to the days of Terah, to that of 205 years; and as the greateſt part of Jacob's numerous family lived to the age of 120 years and upward, we may conſider that period to have been the ordinary age of mankind in that particular era.

Such was the longevity of human life at ſundry periods of time. Firſt before the flood. Secondly 898 years after the flood. Thirdly in the year 76: and fourthly, from the year 1635 to the year 1783 of the Chriſtian era. All of which circumſtances ſeem to coincide with the operations of nature before mentioned. Hence it appears, that the cauſes aſſigned for the various periods of human life have ſome foundation in nature; and therefore ſeem to corroborate the concluſions we have drawn, with reſpect to the primitive ſtate of the earth, the deluge, and the production of mountains, continents, and their effects on the temperature of the air, the ſeaſons of the year, and the longevity of mankind: and therefore it is preſumed, that future obſervations may give theſe reaſonings a laſting foundation. But however that may be, I have not at preſent diſcovered that any part of the work hitherto advanced, is in any degree repugnant to the laws or operations of nature, or to the ſcripture account of the creation; and their agreement I conſider as a further teſtimony of the truth of each; for when thoſe relations are compared together, they ſeem to ſtrengthen the preceding conjectures beyond a poſſibility of doubt.

And if I am not much miſtaken, theſe deductions throw ſome light upon the ſuppoſed poetical fables of Homer, Heſiod, Ovid, &c. and ſhew that their works were not altogether fiction, but were derived from ſundry phenomena in the natural world, or from hiſtories thereof, of the moſt remote antiquity. Theſe inquiries only fall within the province of the learned, and therefore I ſhall return to the remaining part of the ſubject; which is to inquire into the firſt appearance of the rainbow.

CHAP. XV.

Concerning the Appearance of the Rainbow after the Flood.

HAVING inquired into the ſtate of the atmoſphere in the antediluvian world, and its effects on the period of human life, let us extend our reſearches a little further, and endeavour to aſcertain the era when the rainbow firſt appeared.

That phenomenon is well known to ariſe from the rays of light refracted from ſpherical drops of rain deſcending toward the earth: therefore the appearance of the rainbow depends altogether on there being rain or no rain before the flood.

According to the preceding chapters, the antediluvian atmoſphere was more conſtant and uniform in its temperature, and more homogeneous than that in the poſtdiluvian world: for in the former there were no fiſſures or volcanos to impregnate the air with noxious vapours; nor continents to produce extremes of heat and cold: but on the contrary, harmony ſeems to have reigned univerſally over the new-formed globe.

Hence it appears, that the primitive ſtate of the earth was alſo more free from ſtorms and tempeſts than the preſent ſtate and condition of it, and conſequently more free from rain.

It is a general obſervation with mariners, that thoſe parts of the ocean the moſt diſtant from land are the leaſt ſubject to ſtorms and tempeſts: nay, further, that ſtorms are a certain indication of its vicinity.

Don Antonia de Ulloa obſerves, in his Voyage to America, vol. i. p. 13, that "in the ocean, the winds "are ſo mild, that the motion of the ſhip is hardly per-"ceived, which renders the paſſage extremely agreeable. "The atmoſphere of the ocean," ſays he, "anſwers to "the calmneſs of the winds and ſea; ſo that it is very "ſeldom an obſervation cannot be taken either from "the ſun's being obſcured, or the hazineſs of the ho-"rizon."

Varenius remarks, that "the winds are moſt conſtant "in the Pacific Ocean, viz. that part of it which lies "between the tropics; ſo that the ſhips which come "from Aquapulco, a port in New Spain, in America, "to the Philipine iſlands, that is from eaſt to weſt, "often ſail three months, without ever changing or "ſhifting their ſails; having a conſtant eaſt or north "eaſt wind. Nor did ever any ſhip yet periſh in that "vaſt voyage of one thouſand ſix hundred miles. And

" therefore the ſailors think they may ſleep there ſe-
" curely: nor is there any need of taking care of the
" ſhip when that general wind carries them ſtrait to their
" deſired port, the Philipine iſlands. And thus it is
" alſo in ſailing from the Cape of Good Hope, to Bra-
" ſil in America, in the middle of which voyage lies the
" iſle of St. Helena." Varenius' Geog. vol. i. p. 493.

" Dr. Halley, a perſon well ſkilled in meteorology,
" as well as in all parts of phyſics, has, with extraordi-
" nary accuracy, proſecuted the hiſtory of the conſtant
" periodical winds, which he deduces not only from the
" obſervations of ſeamen, but from his own experience.
" But he only takes notice of ſuch winds as blow in the
" ocean; there being ſo much inconſtancy and variable-
" neſs in land winds, that from them a perſon can
" make out nothing clear or certain." See note to Varenius' Geog. vol. i. p. 496.

Now ſince it appears that the atmoſphere of the ocean is uniform in its temperature, and conſtantly unruffled by ſtorms and tempeſts: though the atmoſphere of continents is continually ſubject to violent emotions, and to great and ſudden changes from one extreme of heat or cold to another; may we not thence conclude, that thoſe vaſt tracts of land are the principal cauſe of the former, as well as of the latter. Therefore, as rain generally accompanies ſtorms, it becomes highly probable that they both ariſe from one and the ſame cauſe, and may be conſidered as inſeparable.

Now as ſtorms and tempeſts only commenced with the production of mountains and continents, it ſeems highly probable, that rain alſo commenced at the ſame time.

Therefore, as an uniform temperature univerſally prevailed in the antediluvian atmoſphere, it is highly probable that it was not ſubject to ſtorms and tempeſts, and conſequently not to rain; and if there was no rain, moſt certainly no rainbow.

Hence the firſt appearance of the rainbow ſeems to have commenced at the time of the deluge, with the production of mountains, continents, &c. Its appearance therefore, at that particular era, is conſiſtent with the general order and progreſſion of things.

It may, however, be objected, that a want of rain for ſo many hundred years, as from the creation to the deluge, would be greatly injurious, if not totally deſtroy the vegetable kingdom: but we preſume ſuch objections will vaniſh when the ſtate and condition of the primitive iſlands is truly conſidered.

1. The ſcorching heats of ſummer, and the ſeverities of winter, were not commenced.

2. The ſuperficial contents of the iſlands being ſo much inferior to that of the continents, the ſurface of

the ſea, and the quantity of aqueous particles exhaled, were proportionably greater.

3. The atmoſphere being thus more plentifully ſaturated with humidity, the latter deſcended more copiouſly in dews, during the abſence of the ſun, and abundantly repleniſhed the earth; rendered its ſurface ſoft and ſucculent, and its vegetable productions luxuriant.

Such being apparently the ſtate and condition of the antediluvian world, we cannot ſuppoſe that rain was in the leaſt neceſſary, either for the animal or the vegetable creation: and therefore, during that long period, it is highly improbable there ſhould have been either rain, or a rainbow: for as the cauſes productive of rain only commenced at the time of the deluge, may we not conclude, that the appearance of the rainbow could not precede that era.

Having now completed my inquiries into the original ſtate and formation of the earth, and the changes it has undergone, I purpoſe giving ſome acccount of the *ſtrata* in Derbyſhire, and their various productions of animal, vegetable, and mineral ſubſtances, as an illuſtration of the preceding chapters.

CHAP. XVI.

Of the Strata in Derbyſhire and other parts of England.

THE following obſervations on the *ſtrata* of the earth, are not only intended as an illuſtration of the preceding inquiries, into the original ſtate and formation of the earth, and the great changes it has undergone; but likewiſe to repreſent the advantages ariſing from a ſyſtem of ſubterraneous geography—A ſcience not merely ſpeculative, but ſubſervient to the purpoſes of human life; by leading mankind to the diſcovery of many things of great utility which lay concealed in the lower regions of the earth.

The arrangement of the *ſtrata* in general is ſuch, that they invariably follow each other, as it were, in alphabetical order, or as a ſeries of numbers; whatever may be their different denominations.

I do not mean to inſinuate that the *ſtrata* are alike in all the different regions of the earth, either with reſpect to thickneſs or quality; for experience ſhews the contrary. But that the order of the *ſtrata* in each particular part, how much ſoever they may differ, as to quality, yet they follow each other in a regular ſucceſſion, both as to thickneſs and quality: inſomuch that by knowing the incumbent *ſtratum*, together with the arrangement thereof in any particular part of the earth, we come to a perfect knowledge of all the inferior beds, ſo far as they have been previouſly diſcovered in the adjacent country; of which the following pages contain many inſtances.

With reſpect to the *ſtrata* accompanying coal, I have obſerved ſome inſtances which apparently contradict that general rule, though they do not in reality.

The mountainous part of Derbyſhire affords innumerable inſtances of the uniform arrangement of the *ſtrata*, and alſo of their various productions of animal, vegetable, or mineral ſubſtances, or rather of the figures or impreſſions of the two former. And theſe diſcoveries have ariſen from the numerous perforations through the *ſtrata* in ſearch of minerals, and alſo from the violent convulſions which they have ſuffered, anterior to hiſtory or tradition; whereby the *ſtrata*, which lay in the lower regions of the earth, were thrown up to the ſurface.

I ſay by means of ſuch operations of nature and art, the thickneſs, quality, and poſition of the *ſtrata*, have been truly aſcertained, as repreſented in the ſections given at the end of the work.

And

And in order to render the different denomination of the *ſtrata* obvious by inſpection, I have attempted to aſſign a particular character to each of them, by hatched lines, as colours are repreſented in coats of arms; conſidering that a faithful repreſentation of the *ſtrata*, to be a matter of much importance, not only to the maintainers of mines, but alſo to practical miners; preſuming they may be enabled thereby, to proſecute their mineral reſearches with more propriety and advantage to themſelves and to the public.

It is not only in mineral operations that faithful records of the *ſtrata* are requiſite, but alſo in attempting to diſcover either ſalt or freſh-water ſprings, coal, &c. therefore in order to render the ſubject of ſubterraneous geography of general uſe; whether pits are dug for water or minerals, ſuch records will be found beneficial: for the more general the obſervations, the more concluſive the inferences thence deduced. I am very doubtful whether the mode I have choſen is the beſt poſſible for that purpoſe, and therefore, ſhould gladly receive any hints tending toward the improvement of ſo valuable a branch of ſcience.

It was my intention to have depoſited ſpecimens of each *ſtratum*, with its productions, in the Britiſh Muſeum, arranged in the ſame order upon each other, as they are in the earth; being perſuaded that ſuch a plan would convey a more perfect idea of ſubterraneous geography, and of the various bodies contained in the earth, than words or lines can poſſibly expreſs: and though I have not hitherto been able to complete this deſign, yet I am ſtill in hopes of doing it ſome future day.

It is not my intention to enter into a minute deſcription of the various ſtones, minerals, petrefactions, &c. but rather to repreſent the general ſtate and condition of the *ſtrata*, and the changes they have undergone from various cauſes. Neither do I aſſume to myſelf the ſole honour of the following obſervations, having principally obtained them from ſeveral experienced miners; and particularly from Mr. George Tiſſington, late of Winſter.

I have, indeed, very aſſiduouſly endeavoured to aſcertain the truth of their reports by ſubterraneous viſits, &c. and have alſo made ſome diſcoveries unnoticed by any other perſon before me: therefore, I am not conſcious of any miſrepreſentations, ariſing either from neglect or a theoretical influence; neither am I inſenſible that much more remains to be done, and that in works of this nature, errors are unavoidable.

Plate I. fig. 6. repreſents a ſection of the *ſtrata* between Grange Mill and Darley Moor. The upper outline ſhews the ſurface of the earth; the numbers 1, 2, 3, 4, &c. the reſpective *ſtrata*. Under the river Derwent

went is repreſented a fiſſure filled up with rubble; knowing that to be the ſtate of all vallies wherein ſhafts have been ſunk.

Nº 1. Millstone Grit, 120 yards. A coarſe ſandſtone, compoſed of granulated quartz and quartz pebbles. The former retain the ſharpneſs of fragments newly broken, the latter are rounded by attrition as ſtones upon a ſea beach. This *ſtratum* is not productive of minerals, nor figured ſtones repreſenting any part of the animal or vegetable kingdoms.

The quartz pebbles contained in this *ſtratum*, indicate the pre-exiſtent ſtate of a quartzoſe *ſtratum*; for it is equally well-known that quartz is a ſubſtance only generated in the fiſſures of a quartoze *ſtratum*, as ſpar is found in thoſe of limeſtone; and is not to be conſidered as parts of a *ſtratum*. Quartz pebbles therefore evidently ſhew the deſtruction of a quartzoſe *ſtratum*, the fragments whereof were rounded by attrition.

The quartz pebbles abovementioned are white; the colour of the quartzoſe ſtones from whence they are produced is various, as black, brown, &c. They are in common uſe for paving ſtreets, and are frequently variegated with ſeams of white quartz running through them. They are the common gravel ſtone of Nottinghamſhire, Staffordſhire, Derbyſhire, Cheſhire, &c.

Quartz, or quartzoſe ſtone is analogous to flint; it ſtrikes fire with ſteel, and reſiſts acids: it is leſs hard than flint, and breaks with a rough ſurface.

We are told that the minerals in Norway and Sweden are contained in the fiſſures of a quartzoſe ſtone.

N° 2. SHALE or SHIVER, 120 yards. A black laminated clay, much indurated; it contains neither animal nor vegetable impreſſions, and is not conſidered as productive of minerals, as lead ore, ſpar, &c. though an inſtance or two has appeared to the contrary, in a mine called Shaw Engine, near Eyam, attended with a curious circumſtance; namely, a vein of lead ore in N° 3, aſcended into N° 2, fifteen or twenty fathoms; and the higher it aſcended, the leſs and leſs it was mineralized, till it terminated in a white mucus-like ſubſtance. I had this information from people of veracity. Query, Was the ore generated from the mucus-like ſubſtance? or was that ſubſtance the product of ore decompoſed by the acid contained in that *ſtratum*?

The above *ſtratum* contains ironſtone in nodules, and ſometimes ſtratified. The ſprings iſſuing from it are of the chalybeate kind: for inſtance, one near the bridge at Buxton, one at Quarndon, and another beyond Matlock Bridge, toward Chatſworth.

Shale near the
B. at Buxton

N° 3. LIMESTONE, 50 yards. Productive of lead ore, the ore of zinc, calamine, pyrites, ſpar, fluor, cauk, and chert. The *ſtratum* alſo contains figured ſtones, repreſenting various kinds of marine animals; as a great variety of *anominæ bivalves*, not known to exiſt in the Britiſh ſeas; alſo *coralloids*, *entrochi* or ſcrew-ſtones. I do not recollect ever ſeing any univalves.

The impreſſion of a crocodile was found in the above bed of ſtone, at Aſhford, by Mr. Henry Watſon of Bakewell.

The above *ſtratum* is compoſed of various *laminæ*, more or leſs ſeparated by ſhale or ſhiver, a ſubſtance ſimilar to N° 2; eſpecially the upper, which are a good black, take a fine poliſh, and are thence called black marble. The lower *laminæ* are rather brown, as may be obſerved in the rocks compoſing Matlock High Tor. The ore of zinc, commonly called black-jack or mock-ore, is but recently diſcovered as the ore of zinc. The appellation of mock-ore might probably ariſe from its ſimilitude to lead ore. When compounded with copper it makes braſs, as calamine. Calamine, though ſimilar in its mineral qualities, is apparently a ſimple brown earth; it is commonly uſed in medicine by the name of *lapis calaminaris*.

N° 4. Toadstone, 16 yards. A blackiſh ſubſtance, very hard; contains bladder-holes, like the *ſcoria* of metals, or Iceland lava, and has the ſame chymical property of reſiſting acids. Some of its bladder-holes are filled with ſpar, others only in part, and others again are quite empty. This *ſtratum* is not laminated, but conſiſts of one entire ſolid maſs, and breaks alike in all directions. It does not produce any minerals, or figured ſtones repreſenting any part of the animal or vegetable creation, nor any adventitious bodies enveloped in it; but is as much an uniform maſs as any vitrified ſubſtance whatever: neither does it univerſally prevail, as the limeſtone *ſtrata*; nor is it, like them, equally thick; but in ſome inſtances varies in thickneſs from ſix feet to ſix hundred, as will be ſhewn hereafter. It is likewiſe attended with other circumſtances which leave no room to doubt of its being as much a lava as that which flows from Hecla, Veſuvius, or Etna.

The various circumſtances relative to this apparent lava will be conſidered in their due place, with ſome attempt to inveſtigate the cauſe of its introduction between the limeſtone *ſtrata*; and to ſhew why it did not overflow the ſurface of the earth, according to the uſual effects of volcanic eruptions.

It is to be remembered that the above *ſtratum* is known by different names in different parts of Derbyſhire, viz. at Matlock and Winſter, *toadſtone* and *black-ſtone*; at Moneyaſh and Tideſwell, *channel*; at Caſtleton, *cat-dirt*; at Aſhover, *black-clay*.

N° 5. LIMESTONE, 50 yards. This *ſtratum* is laminated like the former, N° 3, and contains all the ſame kinds of minerals and figured ſtones. It is likewiſe productive of the Derbyſhire marble, ſo much eſteemed for its beauty and excellence in ſlabs and chimneypieces. It abounds more plentifully with *entrochi*, or ſcrew-ſtones, than any other marine productions. The quarry from whence this marble is commonly raiſed, is ſituate on Moneyaſh Moor, near the road, between that town and Bakewell; its colour is grey.

N° 6. TOADSTONE, 46 yards. This *ſtratum* is ſimilar to N° 4, in colour and chymical properties; but yet more ſolid, and freer from bladder-holes, as may be obſerved in Moſeymeer mine, near Winſter.

N° 7. LIMESTONE, 60 yards. Laminated like the former N° 3 and 5, and like them contains minerals, and figured ſtones; but fewer of the latter. Its colour is much whiter than N° 5.

N° 8. TOADSTONE, 22 yards. This *ſtratum* is ſimilar to N° 6, but yet more ſolid, as may be obſerved in Hubberdale mine, near Moneyaſh.

N° 9. LIMESTONE, not yet cut through. Productive of minerals and figured ſtones, like the former, N° 3, 5, and 7, but very few of the latter.

N. B. NO VEGETABLE FORMS HAVE YET BEEN DISCOVERED IN ANY OF THE LIMESTONE STRATA.

Such are the Derbyſhire *ſtrata*, and their productions, qualities, and characters by which they are repreſented plate I. fig. 1. and it is neceſſary to obſerve further, that the ſame characters are applied to expreſs the ſame qualities, in all the other ſections.

To the above we may add ſix other *ſtrata*, which are too minute to be expreſſed on the ſame ſcale: theſe are uſually called *clays*, or *way-boards*; in general they are not more than four, five, or ſix feet thick, and in ſome inſtances not more than one foot. Their colour is a lightiſh blue, with a ſmall tint of green; they all contain pyrites and ſpar in ſmall nodules; and it has been obſerved by Mr. George Tiſſington, that all the ſprings flowing from them are warm, like thoſe at Buxton and Matlock Bath. Theſe clays are calcarious, and may therefore be claſſed with marles. They are arranged in the following order:

Pyrites

warm Springs

The firſt *ſtratum* of clay ſeparates N° 3 and 4; the ſecond, N° 4 and 5; the third, N° 5 and 6; the fourth, N° 6 and 7; the fifth, N° 7 and 8; the ſixth, N° 8 and 9. By theſe clays the thickneſs of the other *ſtrata* are aſcertained, which otherwiſe would be difficult, as the limeſtone beds conſiſt of various *laminæ*.

Having deſcribed the *ſtrata*, aud their various productions contained in plate I. let us take a general view of them. It is to be obſerved that this ſection is only intended to repreſent the arrangement of the *ſtrata*, and not all the particular circumſtances accompanying them, with reſpect to their ſeveral fractures, diſlocations, &c.

To proceed: The lower *ſtrata* appear at the ſurface on Bonſal Moor, and the upper in Darleydale: for inſtance, N° 2, on the banks of the river Derwent; N° 3, in Trogues paſture; N° 4, 5, 6, 7, and 8, on Bonſal Moor, although the elevation of that mountain cannot be leſs than eight hundred or a thouſand feet above the level of the river Derwent. When the lower *ſtrata* thus appear at the ſurface, they are ſaid, by miners, to baſſet.

What has been obſerved of the lower *ſtrata* baſſeting on Bonſal Moor, is likewiſe true in many other parts of Derbyſhire. For inſtance: *ſtratum* N° 2, appears in the vallies of Bakewell, Aſhford, and Caſtleton; and likewiſe on Mam Tor, although that mountain is nearly a thouſand feet above the level of Caſtleton valley. N° 4, forms the ſummit of a mountain adjacent to the caſtle, and is known there by the name of *cat-dirt*. N° 5, forms the ſurface of Moneyaſh Moor, particularly at the marble quarry; and likewiſe at Hubberdale mine, although that mountain cannot be leſs than ſeven or eight hundred feet above the level of Bakewell or Aſhford vallies.

Let us now take a view of plate II. fig. 2; which repreſents a ſection of the *ſtrata* at Matlock High Tor. N° 1, 2, 3, 4, 5, &c. on each ſide the river, ſhew the correſponding *ſtrata*; whence it appears that they have been burſt, diſlocated, and thrown into confuſion, by ſome violent convulſion of nature.

The *ſtrata* which compoſe the top of Maſſon mountain, are elevated about one hundred yards above the ſummit of Matlock High Tor; and the ſame beds are depreſſed about one hundred yards below the foot of it, at the river, as ſhewn in the plate: A, repreſents a great fiſſure or chaſm, filled up with the fragments of the upper and adjacent *ſtrata*.

Such is the general ſtate of the mountainous part of Derbyſhire, which perfectly coincides with the reſult of Chap. XII. p. 119: and therefore, ſerves to ſhew the effects produced by ſubterraneous convulſions; and likewiſe that mountains are not primary productions of nature, but of a very diſtant period of time from the creation of the world.

Whence it appears, that all ſuch vallies were originally great gulfs or fiſſures thus filled up with rubble or fragments of the upper *ſtrata*. Therefore, as the *ſtrata*, N° 1 and 2, have totally diſappeared on the weſt ſide of the river, together with a part of N° 3, the preſumption is great that they have been thus ſwallowed up into that enormous cleft; and if in this inſtance, the ſame thing may have happened in many others; if not univerſally, in all mountainous countries, wherein the upper *ſtrata* have diſappeared. For in Derbyſhire, wherever miners have had occaſion to dig in vallies, they invariably find them thus filled up with fragments of the ſuperior beds.

It may appear ſtrange to our imagination, that ſuch immenſe maſſes of earth ſhould have been thus totally abſorbed into the bowels of the earth; but when we conſider the probability of theſe gulfs being many miles or many hundreds of miles deep, according to Chap. XII. it will no longer remain a matter of wonder what is become of the ſuperincumbent *ſtrata*, ſo often miſſing among the mountains; but rather that thoſe horrid chaſms ſhould have been ſo nearly filled up.

R, repreſents a mine called High Tor Rake. B, B, B, the correſponding fiſſures, ſeparated by beds of toadſtone.

When I ſpeak of incumbent beds, I do not confine myſelf to thoſe of millſtone grit, ſhale, limeſtone, &c. but I alſo include thoſe of argillaceous ſtone, clay, and coal: for according to plate III. fig. 3, and 4; and likewiſe plate IV. fig. 1. wherever *ſtratum* N° 1, dips, or diſappears, as there repreſented, thoſe of argillaceous ſtone, clay, and coal, become the incumbent beds:

therefore, ſince this obſervation holds univerſally true in Derbyſhire, Shropſhire, and Staffordſhire, it ſeems highly probable, that the *ſtrata* of clay, coal, &c. there repreſented, have been originally incumbent on grit, and were ſwallowed up by that dreadful convulſion which burſt the *ſtrata* and threw them into all this diſorder. However that might have been, ſuch is their preſent ſtate; therefore I leave the reader to draw his own concluſions.

Let us now return to plate I. fig. 6. A, A, A, and G, G, G, G, repreſent the correſponding fiſſures in the limeſtone *ſtrata*, interſected by beds of ſolid toadſtone. All the fiſſures thus correſpond in the limeſtone *ſtrata* in Derbyſhire; not a ſingle inſtance knowingly, has happened to the contrary; but it does not follow that they are all thus interſected; for we have many inſtances where the *ſtrata* N° 4, and 6, do not exiſt, as will be ſhewn hereafter: neither are they equally thick, as repreſented in the ſection, although the upper and lower ſurfaces of the other *ſtrata*, are nearly parallel; but more of this in its due place.

It is a general obſervation, and invariably true, that minerals are only contained in the fiſſures of limeſtone *ſtrata*, and between their *laminæ*, and not in the ſolid ſubſtance of the ſtone. When they are diſcovered in the fiſſures, the mines are called rake-works: when between the *laminæ*, pipe-works.

The following mines are inſtances of the ſeveral limeſtone *ſtrata* producing lead ore.

Yateſtoop in *ſtratum* - - - N° 3.
Portaway and Placket in - - N° 5.
Moſeymeer in - - - N° 7.
Gorſeydale in - - - N° 9.

All the *ſtrata*, except toadſtone, may be conſidered as equally thick, when covered by an incumbent bed; but when expoſed to the operations of the air, they are greatly diminiſhed in thickneſs, or decompoſed as it were, and changed to a vegetable mould, whether grit, limeſtone, or toadſtone: for it is obſervable, that the effects of the weather extend many feet below the ſurface of the earth. Immediately under the ſoil, the fragments of the ſtone are ſmall, and gradually increaſe in bulk to the depth of fifteen or twenty feet, where the *ſtratum* generally becomes ſolid, and fit for the maſon.

We have now to obſerve of the *ſtrata* in general, that wherever N° 1 appears on the ſurface, N° 2 lies certainly underneath it; where N° 2 forms the ſurface, N° 3 is the ſucceeding *ſtratum*; and this holds true with all the other *ſtrata*, where any obſervations have been made, the toadſtone excepted: and therefore

fore ſince grit and ſhale are now only to be found in broken detached parts, diſperſed over the mountainous parts of Derbyſhire; it appears highly probable, that they have originally prevailed univerſally over that part of the country, according to our obſervations on the argillaceous ſtone, clay, coal, &c.

Let us now take ſome notice of the toadſtone, ſince it appears to have been formed by a different cauſe.

We have already obſerved, that toadſtone interſects the mineral veins, and totally cuts off all communication between the upper and the lower fiſſures.

Hence it is that when a mineral vein in N° 3, is cut down to N° 4, all mineral appearances totally vaniſh. But experience, the great maſter in phyſical reſearches, has taught the miner to dig through the toadſtone to the limeſtone N° 5, where he never fails finding the correſponding vein, as above repreſented, or nearly ſo.

The above facts may be conſidered as univerſally true; and therefore merit a particular attention, as they will be called forth hereafter to prove the origin of toadſtone.

Another circumſtance accompanying toadſtone, is, the cloſeneſs of its texture; a property of great utility in the practice of mining: for inſtance, ſuppoſe the ſprings in a mine at I. plate I. fig. 6. near Wenſley, were either too powerful, to be raiſed by an engine, or the expence of raiſing them too great; the work then ſtands, and a ſhaft is ſunk at an upper level at O, down to N° 5 at *a*, and a gate or gallery driven under N° 4 to the correſponding fiſſure at G. This is a common practice among the miners in Derbyſhire, and never fails producing a dry work in *ſtratum* N° 5; for the cloſe texture of the toadſtone will not filtrate water ſufficient to incommode the workmen, although it may be ten or fifteen fathoms deep in N° 3, as repreſented by the horizontal line L, L. This circumſtance likewiſe ſhews that the toadſtone is free from fiſſures.

Another circumſtance accompanying toadſtone, is, that it frequently fills up fiſſures in the limeſtone *ſtrata* immediately under it, and this, more or leſs, as they are more or leſs wide, ſee S, H, plate I. fig. 6. When fiſſures are thus filled up, the miners call it *troughing*. Two ſuch inſtances have been diſcovered on Bonſal Moor; one of them in the mine called Slack; the other in that called Salterway. In the former there are two fiſſures which interſect each other, called a croſs-rake: one of them contains toadſtone, the other minerals. See plate I. fig. 2. A, B, the mineral vein, totally ſeparated by the toadſtone F, F.

It is neceſſary further to obſerve, that a ſhaft was ſunk at this mine forty or fifty fathoms deep in toadſtone,

ſtone, and no bottom yet found. Another ſhaft was ſunk about ſixty yards from the former, toward the eaſt, and the ſame toadſtone was found about twenty fathoms thick. Another ſhaft was alſo ſunk about the ſame diſtance toward the weſt, and the toadſtone was found near twenty fathoms thick. Theſe circumſtances ſeem to ſhew, that the firſt ſhaft was ſunk in a fiſſure.

Similar inſtances are not uncommon, therefore the above may be conſidered as characteriſtic of the mineral part of Derbyſhire.

In the mine called Salterway, a fiſſure has been diſcovered in part filled up with toadſtone, and in part with the fragments of limeſtone, minerals, &c. See the ſection plate I. fig. 3. F, F, F, repreſents the toadſtone.

On Tideſwell Moor, the toadſtone, or channel, as there called, has been dug one hundred fathoms deep, and no bottom found; though in ſeven other mines adjacent, the ſame *ſtratum* has been dug through, and its thickneſs aſcertained at each place, as under.

Names of the Mines.			*Fathoms.*
A. Black Hillock	-	-	100 not cut through.
B. Heath Buſh	-	-	16 cut through.
C. St. Andrew's	-	-	2 ditto.
D. St. James'	-	-	12 ditto.

E. Con-

Names of the Mines.	*Fathoms.*
E. Conſtant - - -	7 cut through.
F. Calveſtone - - -	7 ditto.
G. Dunkirk - - -	19 ditto.
H. Chapmaiden - - -	17 ditto.

Plate IV. fig. 2. ſhews the ſituation of each ſhaft where the obſervations were made, by Mr. William Haigh of Tideſwell.

The above may ſerve to ſhew that toadſtone is ſo extremely variable in its thickneſs, as not to admit of being truly repreſented by a ſection. Let us now enumerate a few inſtances where this ſtone has not yet been found, viz.

In the mines at Eyam and Foolow, although thoſe mines are ſunk near fifty fathoms in the limeſtone; and the *ſtratum* N° 5, forms the ſurface of the earth at Foolow.

The *ſtrata* N° 4 and 6, are not univerſal; they have no exiſtence in Hubberdale mine, near Moneyaſh; Hangworm mine, on Bonſal Moor; nor at Highrake mine, near Tideſwell.

Hence it evidently appears, that toadſtone is attended with many peculiar circumſtances very different from the other *ſtrata*. 1. It is perfectly ſimilar to Iceland lava in its appearance and chymical quality. 2. It is extremely variable in its thickneſs. 3. It is not univerſal. 4. It has no correſponding fiſſures to thoſe in limeſtone. 5. It frequently fills up the fiſſures in the *ſtratum* underneath it, more or leſs, as they are more or leſs wide.

All theſe circumſtances plainly evince, that toadſtone was formed by a very different law from the others, and greatly poſterior to them; for the beds of limeſtone muſt have been formed before they were broken, and broken before their fiſſures were thus filled up: therefore we may, with much reaſon, conclude, that *toadſtone*, *channel*, *cat-dirt*, and *black-clay*, is actual lava, and flowed from a volcano whoſe funnel, or ſhaft, did not approach the open air, but diſgorged its fiery contents between the *ſtrata* in all directions. Another remarkable phenomenon accompanying the Derbyſhire lava is, that the *ſtratum* of clay lying under N° 6, is apparently burnt, as much as an earthen pot or brick; inſomuch that when compared to the burnt clay on Heynor Common, they are not to be diſtinguiſhed aſunder. The Heynor clay was burnt by a *ſtratum* of coal being on fire underneath it, and is the beſt material in that neighbourhood for the repair of public roads. This argillaceous ſtone, though much indurated, ſoon returns to its primitive clay by the preſſure of coal carriages.

The calcined clay, mentioned above under N° 6, is not peculiar to any one mine, but is commonly obſerved in all mines. The part in contact with the toadſtone is burnt about one foot thick.

Having enumerated the various circumſtances relative to toadſtone, there can be but little doubt of its being actually a volcanic production. However probable that may appear, the intelligent reader may poſſibly aſk by what proceſs lava was introduced between ſuch immenſe beds of ſtone?

The queſtion is more eaſily ſtated than anſwered, yet ſeems to require a ſolution to eſtabliſh its identity. We will therefore attempt the inveſtigation, difficult as it may appear: for ſhould we fail in the attempt, future diſcoveries may poſſibly afford a more ſatisfactory ſolution.

Previous to the inquiry, it is neceſſary to obſerve, that the introduction of lava between the limeſtone *ſtrata* was anterior to the fracture repreſented plate II. fig. 2. This is evident from the correſponding *ſtrata* on each ſide the river, and alſo from the fragments of the toadſtone contained in the fiſſure. Theſe circumſtances likewiſe ſhew that the poſition of the *ſtrata* was altered by the convulſion which occaſioned the fracture, whence we may infer they had originally an uniform arrangement, concentric to the centre of the earth. And if in this inſtance, may we not conclude, by analogy, that ſince all the mountainous part of Derbyſhire is in a ſimilar ſtate of confuſion, that they have been diſordered from a ſimilar cauſe; and conſequently all its *ſtrata* muſt have had originally an uniform arrangement at the time lava was introduced between them.

This being granted, it will then follow, that the *ſtrata* of grit and ſhale, which are now only found in broken detached maſſes, variouſly diſperſed over the north part of Derbyſhire, univerſally prevailed, or were ſuperincumbent on limeſtone. And by parity of reaſon it will hold equally true, that the *ſtrata* of argillaceous ſtone, clay, and coal, repreſented plate II. III. IV. were alſo univerſally incumbent on grit. Such I conceive to have been the original ſtate and condition of the *ſtrata* prior to the convulſion which threw them into their preſent ſtate of diſorder.

Having premiſed theſe matters, let us conſider by what apparent cauſe lava could have been introduced between the limeſtone *ſtrata*, at a time when they were compreſſed by ſuch an immenſe incumbent weight of ſhale, grit, argillaceous ſtone, clay, and coal; and likewiſe ſhew why the lava did not burſt open a paſſage and overflow the ſurface of the earth.

Firſt, According to Chap. XII. ſubterraneous fire prevailed univerſally, either in the ſame *ſtratum*, or in the central part of the earth, as repreſented plate I. fig. 1.

Secondly, The expanſive force of this fire elevated, and burſt the incumbent *ſtrata*, prior to the convulſion which threw them into their preſent ſtate of confuſion.

Fiſſures being thus opened over the melted matter, the violent preſſure of the incumbent weight might cauſe it to aſcend till it met with an obſtruction ſuperior to the impelling force.

Let us now ſuppoſe, for the preſent, that if the lava was thus circumſtanced, it would conſequently have a lateral preſſure proportionable to the impelling force; and therefore might probably penetrate between the *ſtrata*, and force its way, till it loſt its fluidity by the coldneſs of the adjacent beds. Being thus extended to ſome diſtance, and paſſing over other fiſſures, it might fill them up more or leſs, as they happened to be more or leſs wide, and the lava more or leſs fluid.

Hence, I preſume, the fiſſures in the Salterway mine being only in part filled up with lava, was owing to the above cauſe. See plate I. fig. 3, F F F, the lava.

Now ſince it appears that the ſhaft in Black Hillock mine, was ſunk one hundred fathoms or 200 yards deep in lava, there is ſome probability that it flowed from the bowels of the earth, up that fiſſure, and ſpread itſelf laterally in all directions; and this conjecture is ſtrengthened by the various thickneſſes of the ſame maſs of matter at the different mines, laid down in the plan plate IV. fig. 2.

We have now to conſider why the lava did not overflow the ſurface of the earth.

It has already been obſerved, that lava was introduced between the *ſtrata* during their uniform arrangement, and while the beds of argillaceous ſtone, clay, coal, grit, and ſhale, were univerſally incumbent on limeſtone.

Now it ſeems highly probable that ſhale, at ſo remote a period, was a ſoft, ductile ſubſtance, more ſubject to extenſion by an internal expanſive force, than to crack or break, like the limeſtone, which was perfectly concreted: therefore ſince that *ſtratum* is one hundred and twenty yards thick, and was covered by a *ſtratum* of grit of the ſame thickneſs, and that grit by all the beds of argillaceous ſtone, &c. amounting to ſeveral hundred yards more; it ſeems highly probable, that the united reſiſtance of ſo much incumbent weight, together with the quantity and quality of the ſhale, might totally obſtruct the lava in its paſſage toward the ſurface, and cauſe it to ſpread laterally between the limeſtone *ſtrata*.

Such are the conjectures which at preſent occur to me, why the melted matter did not approach the ſurface of the earth, according to the uſual mode of volcanic operations.

Having now compleated my obſervations on the Derbyſhire lava, and on the general ſtate and condition of the *ſtrata* productive of lead ore, &c. I propoſe to enlarge my obſervation on the argillaceous *ſtrata* productive of coal.

Plate II. fig. 1. repreſents a ſection of the *ſtrata*, eaſt and weſt of the river Derwent, from Belper Ward toward Blackbrook. In this ſection, N° 1 dips or diſappears at the river; and thoſe of argillaceous ſtone, clay, and coal, become the ſuperior beds, and are characterized accordingly. For inſtance, *a a a a a a*, repreſent the argillaceous ſtone; *b b b b b* clay, bind, or clunch, ſynonymous terms; *c c c* coal. The upper *ſtratum* of argillaceous ſtone is excellent for the uſe of cutlers' grindſtones, and carpenters' whetſtones. It is of a browniſh colour, and may be obſerved in all the roads about Smalley, Heynor, Denby, Heage, Pentridge, Alfreton, Carnfield, Cheſterfield, Sheffield, &c. It does not efferveſce with acids; and, as it has already been obſerved, when applied to the repair of roads ſoon returns to its primitive clay.

Whetstones

The lower *ſtrata* are much harder, will ſtrike fire with ſteel, and are more durable and fit for the buſineſs of the roads. Theſe beds are more white, and are commonly called crow-ſtone.

The beds of clay, clunch, or bind, are much indurated, and appear like ſtone, but ſoon diſſolve by the weather.

All the above *ſtrata*, incumbent on coal, whether argillaceous ſtone or clay, contain a great variety of vegetables, or the impreſſions of them; and particularly the bamboo of India, ſtriated and jointed at different diſtances; the *euphorbia* of the Eaſt Indies, the American ferns, corn, graſs, and many other ſpecies of the vegetable kingdom, not known to exiſt in any part of the world in a living ſtate. They are incloſed in the ſolid ſubſtance of ſtone and clay.

Theſe vegetable forms, and the *ſtrata* containing them, are a certain indication of coal, not only in Derbyſhire, but in every part of this kingdom which I have viſited: and I am informed, that the ſame appearances hold equally true in every other part of the world yet explored; of which ſome inſtances will hereafter appear.

Sir Aſhton Lever's incomparable muſeum of natural curioſities, contains the moſt perfect ſpecimens and the greateſt variety of foſſil vegetables, if I may be allowed to call them ſo, I ever ſaw.

Now ſince it appears that all *ſtrata* accompanying coal, univerſally abound with vegetable forms, it ſeems to indicate that all coal were originally derived from the vegetables thus enveloped in the ſtone or clay: and we may ſay as much of the origin of iron; for the ſame *ſtrata* alſo produce ironſtone; for wherever vegetables are obſerved to decay in ſtagnant ditches, the waters thereof appear ochrey.

It is a matter worthy notice, that the ſuperior *ſtrata* contain ironſtone, coal, and vegetable impreſſions, but NO MARINE PRODUCTIONS WHATEVER. And that the inferior *ſtrata*, which are limeſtone, contain the *exuviæ* of marine animals, but NO VEGETABLE FORMS.

Such is the arrangement of the *ſtrata* in Derbyſhire, ſo far as my obſervations have hitherto extended; and not only in Derbyſhire, but in Staffordſhire, Shropſhire, Wales, and Ireland.

We have now related ſome general truths reſpecting the conſtruction of the earth, or the arrangement of its *ſtrata*, which may ſerve to point out the probability of coal or limeſtone being contained in the lower regions of the earth.

1. That the coarſe millſtone grit, deſcribed page 182, is never incumbent on coal, but always incumbent on limeſtone.

2. That argillaceous ſtone, clay, and coal, is always incumbent on grit.

Hence appears the neceſſity of conſtructing a muſeum compoſed of the different *ſtrata*, and their various productions of animal, vegetable, and mineral ſubſtances, arranged in the ſame order they are in the earth. This would convey a perfect idea of the bodies themſelves, and ſhew us the order in which the reſpective *ſtrata* were ſucceſſively formed: for thoſe containing marine productions only, muſt certainly have been formed while the ſea covered the earth; and thoſe containing vegetables, and no marine *exuviæ*, muſt have been formed after the earth became habitable. It is therefore apparently repugnant to the general courſe of nature, that terreſtrial animals and vegetables ſhould be blended together with marine productions; we therefore conſider the limeſtone *ſtrata* as primitive beds, much anterior to the argillaceous *ſtrata*, or coal; and likewiſe that all coal and iron, were originally derived from vegetation.

But indeed the *ſtrata* have been ſo frequently deranged, that the order of nature is in ſome inſtances apparently inverted, and particularly in the following caſe.

"In the whole city of Modena, and round about "for ſome miles diſtance, in whatever place they dig, "when they come to the depth of about ſixty-three "feet, they pierce the ground with a *terebra* or auger,

" about five feet deeper, and then the water ſprings " up with ſo great force, that in a moment the well is " filled up to the brim. This water is perpetual, doth " not increaſe by rain, nor decreaſe by drought; " and, what is yet more remarkable, from the ſurface " of the ground to the depth of fourteen feet, they meet " with nothing but rubbiſh and ruins of an ancient " city. Being come to that depth, they found paved " ſtreets, artificers ſhops, floors of houſes, and ſeveral " pieces of inlaid-work.

" It is very hard to conceive how the ground of this " city was raiſed thus; we can attribute it to nothing " elſe, but that it hath been ruined, and afterward " rebuilt upon its ruins; ſince it is not higher, but rather lower ſtill than all the adjacent country.

" After theſe ruins they find a very ſolid earth, " which one would think had never been removed; " but a little lower they find it black and marſhy, and " full of briars. Signor Rammazzini went down one " of theſe wells, and at the depth of twenty-four feet " he found a heap of wheat intire; in another of " twenty-ſix feet, he found filbert-trees, with their " nuts. They found likewiſe every ſix feet alternately, " a change of earth, ſometimes white, with branches " and leaves of trees of different ſorts.

"At the depth of twenty-eight feet, or thereabouts, "they find a chalk that cuts very eaſy: it is mixed "with ſhells of ſeveral ſorts, and makes a bed of about "eleven feet. After this they find a bed of marſhy "earth, of about two feet, mixed with ruſhes, leaves, "and branches. After this bed comes another chalk "bed of nearly the ſame thickneſs with the former, "which ends at the depth of forty-two feet.

"That is followed by another bed of marſhy earth "like the former. After which comes a new chalk "bed, but thinner, which hath alſo a marſhy bed underneath it. This ends at the place where the workmen bore with their auger. The bottom is ſandy, "mingled with a ſmall gravel, in which they find ſeveral ſhells, ſuch as are on the ſea-ſhores.

"Theſe ſucceſſive beds of marſhy earth and chalk, "are to be found in the ſame order, in whatever parts "of the earth you dig. The auger ſometimes finds "great trees, which give the workmen much trouble. "They ſee alſo, at ſome times, at the bottom of theſe "wells, great bones, coals, flints, and pieces of iron." Ray's Three Diſcourſes, p. 223, 3d edition.

Theſe alternate beds of marſhy earth and chalk may poſſibly be conſidered as a contradiction to what has been obſerved concerning the general arrangement of the *ſtrata*, viz. that all *ſtrata* productive of vegetable impreſſions are ſuperior to thoſe containing marine *exuviæ.* But the only inference apparently to be deduced from the *ſtrata* at Modena is, that the ſuperficial parts of the earth, have ſuffered frequent alterations from ſea to land, and from land to ſea; and not that the *ſtrata* in general were thus formed: therefore, ſuch phenomena require a particular inſpection before we can with propriety draw any concluſions from them reſpecting the general order of the *ſtrata.*

Horse muscles

We have one inſtance in Derbyſhire, ſomewhat ſimilar to the above; namely, a *ſtratum* of ironſtone, plentifully abounding with the ſhells of fiſh: therefore, as ironſtone is generated in the argillaceous beds, and thoſe beds are ſuperincumbent on grit, ſhale, and limeſtone, theſe *exuviæ* may alſo be conſidered as a manifeſt contradiction to the ſuppoſed general order; but it is very eaſy to obſerve, that theſe ſhells are not marine productions, but of freſh-water lakes, rivers, &c. being actually the remains of horſe muſcles.

Tupton Moor
muscles.

The above *ſtratum* of ironſtone extends from Tupton Moor, near Wingerworth, the ſeat of Sir Henry Hunloke, Bart. to Stavely: it is about one foot thick, and lies about eight yards below the ſurface of the earth.

As a farther teſtimony of the general conformity of the *ſtrata,* plate III. fig. 3. repreſents a ſection thereof at Lincoln Hill, near Colbrooke Dale, Shropſhire.

N° 1, 1, 1, 1, *ſtrata* of millſtone grit, ſimilar to N° 1, in the Derbyſhire *ſtrata*. N° 3, limeſtone; P P, *ſtrata* of quartz pebbles; *a a a*, argillaceous ſtone; *b b*, bind; *c c*, coal.

The *ſtrata* about Colbrooke Dale have been ſtrangely ſhattered to pieces, and thrown into great diſorder, as appears by the ſection. Both the argillaceous *ſtrata* and thoſe of limeſtone abound with a great variety of figured ſtones, the former repreſenting the vegetable kingdom, and the latter, thoſe of marine animals.

Plate IV. fig. 1. repreſents a ſection of the *ſtrata* from the new plantation in Chatſworth Old Park, to the river Derwent. N° 1, 2, 3, &c. ſhew the correſponding *ſtrata* on each ſide a ſuppoſed great fiſſure; and likewiſe that although there is a *ſtratum* of coal in the Old Park, there is none in the plantation; owing to the diſarrangement of the *ſtrata*. Theſe are the circumſtances which render the practice of mining very uncertain, to thoſe who do not attend to the quality of the upper *ſtratum*.

Though the fracture repreſented in the ſection is in no degree viſible on the ſurface of the earth; yet, ſince the arrangement of the *ſtratum* N° 1, is conſtantly inferior to that of coal, and that a *ſtratum* of coal, has undoubtedly been diſcovered in the Old Park, it evidently follows that the *ſtrata* have been fractured as repreſented.

Such therefore is the conſtant invariable arrangement of the *ſtrata*, that whenever the *ſtrata* accompanying coal are perforated down to N° 1, it is altogether in vain to proceed any further in ſearch of coal; but particularly in Derbyſhire, Staffordſhire, and Shropſhire, and alſo in Ireland, as will appear hereafter.

It is neceſſary to obſerve, that the ſections repreſenting the *ſtrata* of argillaceous ſtone, clay, and coal, are not laid down by the ſame ſcale with thoſe of limeſtone, &c. Twenty of the former being only equal in thickneſs to one of the latter; I have therefore taken the liberty of reducing their numbers, and increaſing their thickneſs, in order to diſtinguiſh their different qualities by hatched lines.

Hence the following table is inſerted; ſince nothing more is to be underſtood from the ſections, than to repreſent the general arrangement of the *ſtrata*, the ultimate end of ſubterraneous geography.

A TABLE *of the* STRATA *at* ALFRETON COMMON.

	Numb.		Feet.	Inches.
	1	CLAY	7	0
	2	RATCHELL, *fragments of ſtone*	9	0
	3	BIND, *indurated clay*	13	4
	4	STONE, *argillaceous concreted clay*	6	0
	5	BIND	8	8
	6	BIND	25	0
	7	STONE, *a black colour*	5	0
	8	BIND	2	0
	9	STONE	2	0
	10	BIND	5	0
	11	BIND	5	0
			88" 0	
1	12	COAL	1	6
	13	BIND	1	6
	14	STONE	23	0
	15	STONE	14	0
	16	BIND	7	0
			47" 0	
2	17	SMUTT, *a black ſubſtance, reſembling a* ſtratum *of coal-duſt*	3	0
	18	BIND	3	0
	19	STONE	20	0
	20	BIND	16	0
			42" 0	
3	21	COAL	7	4
			184	4

A TA-

A TABLE *of the* STRATA *at* WEST HALLAM.

	Numb.			Feet.	Inches.
	1	CLAY		7	6
	2	BIND	55"6	48	0
	3	SMUTT		1	6
	4	CLUNCH, *indurated clay*		4	0
	5	BIND		3	0
	6	STONE		2	3
	7	BIND		1	0
	8	STONE		1	0
	9	BIND		3	0
	10	STONE		1	0
	11	BIND		16	0
	12	SHALE		2	0
	13	BIND		12	0
	14	SHALE		3	0
	15	CLUNCH, *ſtone and ſometimes cank*	103"9	54	0
1	16	SOFT COAL		4	0
	17	CLAY	4"6	0	6
2	18	SOFT COAL		4	6
	19	CLUNCH *and* BIND		21	0
3	20	COAL	26"0	1	0
	21	BIND		1	0
	22	*Strong, broad* BIND		25	0
4	23	COAL	27"0	6	0
				222	3

Although the preceding obſervations have a tendency to prove that coal is not to be found under a *ſtratum* of limeſtone, yet we have an inſtance to the contrary at Etruria and Little Fenton, near Newcaſtle in Staffordſhire, as follows:

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First *ſtratum*, Ratchell, or fragments of ſtone.
Second, Limeſtone, one foot thick, which contains no figured ſtones.
Third, Sand.
Fourth, Argillaceous ſtone.
Fifth, Bind.
Sixth, Coal.

Here it may be neceſſary to obſerve, that all beds of ſand and gravel are adventitious aſſemblages of matter, and not original *ſtrata*, whence it appears, that the above *ſtratum* of limeſtone is a recent production, formed ſince the ſea retired from that part of the earth, therefore not to be conſidered as interfering with the general order of the *ſtrata*.

The following obſervations ſeem to ſhew, that gravel and ſand are actually aſſemblages of adventitious matter.

1. The river Derwent flows from a gritſtone *ſtratum*, and continues its courſe, ten or fifteen miles, at the

foot of gritſtone mountains; throughout that ſpace, the bed of the river, and its adjacent meadows, abound with rounded gritſtones and ſand, which is manifeſtly the granulated parts of the ſame *ſtratum*.

2. The river Wee continues its courſe many miles, through limeſtone vallies, until it falls into the Derwent at Rouſley: therefore the bed of that river, and its adjacent grounds, where flat, contain limeſtones, chert, and other productions of the limeſtone *ſtrata*, rounded by attrition, and alſo granules of the ſame *ſtrata*.

Thus are the above rivers circumſtanced down to Rouſley, where they unite. From thence to the river Trent, the bed of the Derwent, and its adjacent meadows, contain rounded grit, limeſtone, ſpar, chert, and all the mineral ſubſtances Derbyſhire produces, and likewiſe ſand, as above.

Whence we may reaſonably conclude, that all the above rounded ſtones and beds of ſand, have been actually depoſited by the river Derwent, however diſtant they may be found from its preſent courſe.

For inſtance: wherever a pit is dug in the meadows between Derby and Chaddeſden Hill, the gravel is compoſed of ſuch ſubſtances; and yet the channel of the river has been confined to its preſent ſituation nearly two thouſand years: as appears by the remains of a bridge at Little Cheſter, ſaid to have been conſtructed by the Romans. This ancient ruin is now immerſed a few feet in the river, more than it was forty years ago.

The ſame kind of gravel as above, I ſaw dug up at Oſmaſton, near the ſeat of Sir Robert Wilmot, Bart; the pit was about ſix feet deep: and alſo at Thurlſtone, where a pit is now open for the repair of public roads: and yet both the above places are twenty or thirty feet above the level of the river Derwent, and nearly one mile diſtant.

Qd. oismaster

Theſe inſtances may ſerve to ſhew, that the above beds of gravel and ſand are aſſemblages of adventitious matter, and not original *ſtrata*. Hence we may conclude by analogy, that all beds of gravel whereſoever found, whether on mountains or in vallies, have been depoſited either by rivers or the action of the ſea; and that the ſtones which compoſe them were rounded by attrition, as the ſtones on a ſea-beach, or in rivers.

A little obſervation would furniſh innumerable inſtances of the ſame kind: I well remember ſeeing a gravel pit about a mile ſouth of Uppingham, containing rounded limeſtones, ſea-ſhells, and a *ſtratum* of ſand and gravel. The limeſtone is ſimilar to that of the Ketton quarry, which is peculiar for the figure of its granules which compoſe it, being ſpherical, and have much the appearance of the roes of fiſhes. The ſand is manifeſtly compoſed of thoſe granules, the grains being all of them ſpherical. Now from the various circumſtances attending this gravel pit, as the rounded limeſtones great and ſmall, rounded ſea-ſhells, and ſand; we cannot be a moment in doubt but this very pit muſt have been originally a ſea beach, and that the ſand is the pulverized parts of that ſtone.

The counties of Cheſter and Lancaſter contain many beds of ſand, which are occaſionally dug up for the repair of roads and other purpoſes. Theſe ſand beds are frequently accompanied with a very curious phenomenon. At Mare, near the ſeat of Peter Brook, Eſq; I ſaw a ſand pit, containing the fragments of pit-coal and cinders depoſited in a ſtratified manner through a conſiderable extent of the bank. I have alſo obſerved the ſame appearances at Mobberley near Knutsford, and in the road from Walton-bridge to Worſley in Lancaſhire. In ſhort, I ſcarcely remember ever inſpecting a bank of ſand that was totally free from extraneous bodies, or other evident marks of its having been depoſited by the flowing of water. The above fragments of coal and cinders lay ſix or ſeven feet below the ſurface of the earth. And I have lately been informed by a gentleman of that neighbourhood, that ſuch appearances are not peculiar to the ſand banks of Mare and Mobberley, but that they are almoſt univerſal whereever ſand pits are dug in Cheſhire.

allˡ. Coal

Hence we may conclude, that all beds of ſand and gravel are aſſemblages of adventitious bodies, and not original *ſtrata*: therefore, wherever ſand or gravel form the ſurface of the earth, they conceal the original *ſtrata*, and deprive us of the advantages of judging, whether coal or limeſtone are contained in the lower regions of the earth, and more eſpecially in flat countries where the *ſtrata* do not baſſet.

In countries thus circumſtanced, where coal or limeſtone are wanted, it is adviſable to make a few experiments by digging, or boreing through the gravel or ſand, to aſcertain the qualities of the *ſtrata* underneath; whence we may infer with tolerable certainty what is contained below them.

It rarely happens that the argillaceous *ſtrata* are covered by gravel or ſand; but we have ſome inſtances of it, and therefore there may be many more of them in other parts.

At Nuttall near Nottingham, the beds of ſtone and clay are covered by ſand and gravel five or ſix feet deep: therefore by viewing the ſurface of the earth, not the leaſt appearance of coal can be diſcovered: this inſtance alone may ſerve to ſhew the propriety of experimentally proving the lower *ſtrata*.

all ? nuthall

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What has been obſerved concerning the origin of ſand being the effects of attrition, is only to be underſtood in a limited ſenſe: for if we look upon an ancient ſtone edifice, it is eaſy to obſerve that the ſtone is much impaired or waſted by the weather, and particularly on the ſouth ſide, more than on the north, the former being more expoſed to the ſun, rain, and wind than the latter.

And it has already been obſerved, that if we examine a ſtone quarry we ſhall find its upper ſurface decompoſed as it were, by the operations of the weather, and reduced to grains of ſand, which are continually waſhing down from the mountains and forming beds of ſand in the vallies, rivers, and likewiſe in the ſea.

Hence the origin of gold duſt on the banks of the African rivers, and the irony ſands on the American ſhores.

Thus have the operations of the weather a conſtant tendency to reſtore the ſurface of the earth to its primitive order and regularity.

Having compleated my obſervations on the Derbyſhire *ſtrata*, I purpoſe giving ſome account of an extraordinary phenomenon which has frequently happened in Haycliff and Ladywaſh mines at Eyam; and in Oden mine at Caſtleton: the former are thus circumſtanced.

1. The minerals are contained in the fiſſures of the limeſtone, N° 3, plate I. covered by a *ſtratum* of ſhale

and grit, which retain their full thickneſs of ſixty fathoms each.

2. The minerals contained in the above mines are blended together ſo as to produce the appearance of white Italian marble clouded with black, and are ſo extremely hard and compact as to require blaſting with gunpowder, to ſeparate them from the general maſs.

3. Thoſe in the Ladywaſh vein, are divided in two equal parts parallel to the ſides of the fiſſure, as repreſented by the line *a*, *a*, fig. 4. plate I. They may be compared to two ſlabs of marble, whoſe poliſhed ſurfaces are abſolutely in contact with each other without the leaſt degree of coheſion.

4. Theſe naturally poliſhed ſurfaces are not truly flat, but in ſome degree waved, as if formed by a carpenter's plane, conſiſting of various members.

5. The two ſurfaces are generally coloured with lead ore, thinly laid on, as if only rubbed over with black-lead, though ſometimes much thicker.

6. The vein in Haycliff mine contains two of the above ſeams, and therefore may be compared to three ſlabs of marble, the middle one poliſhed on both ſides and in contact with the other two. The ſeparation of theſe ſlabs is repreſented by the two lines V, V, plate I. fig. 5.

Thus are the above veins circumſtanced. Now what is yet more remarkable is this: if a ſharp pointed pick is drawn down the vein with a ſmall degree of force, the minerals begin to crackle, as ſulphur excited to become electrical by rubbing; after this, in the ſpace of two or three minutes, the ſolid maſs of the minerals explodes with much violence, and the fragments fly out, as if blaſted with gunpowder.

Theſe effects have frequently happened, by which many workmen have been much wounded, but none killed, both in the Eyam mines, and in that called Oden at Caſtleton.

In the year 1738 a prodigious exploſion happened in the mine called Haycliff. The quantity of two hundred barrels of the above minerals were blown out at one blaſt, each barrel, I preſume, contained no leſs than three or four hundred weight. At the ſame time a man was blown twelve fathoms perpendicular, and lodged upon a floor, or bunding, as the miners call it, in one of the ſhafts.

When the above exploſion happened, the barrel, or tub, in which the minerals, &c. are raiſed to the ſurface, happened to hang over the engine ſhaft, which is nearly ſeven feet diameter, and 448 yards diſtant from the forefield, or part, where the exploſion happened; this barrel, though of conſiderable weight, was lifted up in the hook on which it was ſuſpended; and the people on the ſurface felt the ground ſhake, as by an earthquake.

Such are the effects which have frequently been produced in all the above mines; but from what cauſe they proceed, I have not yet been able to diſcover, nor even the leaſt traces toward it. The ſubſtance having been analized, is found to conſiſt of fluor and the ore of lead, but the cauſe of exploſion ſtill remains equally myſterious, though ſome attempts have been made to obtain a knowledge of this curious phenomenon.

Theſe curious obſervations I received from Mr. Mettam of Eyam, overſeer of the mines, who alſo addreſſed the following account of them to Mr. George Tiſſington of Winſter, principal agent of the works.

" SIR, *Eyam*, 2 *July*, 1768.

" I ſend you, by the bearer, two ſpecimens of our " *ſlickenſides* *, containing all the variety of minerals " where the exploſions happen; they fly out in ſuch " *ſlappits* †, ſmooth on one ſide. The exploſions are " ſometimes heard to the ſurface, and felt like an earth- " quake; they frequently blow out all the candles in

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* *Slickenſides*, ſhining, as if poliſhed by art, on one ſide.

† *Slappits*, fragments of the minerals burſt out of the vein.

" the mine, and ſplit the *ſtemples* ‡ into ſplinters as
" ſmall as the twigs of a birch beſom, to the diſtance
" of thirty or forty yards from the *forefield* §; others
" are broke, and ſome of them become too ſhort and
" drop out.

" The ſmooth ſides lie face to face, and have the
" appearance of being ſhot with a plane, conſiſting of
" various members. There is generally two of theſe
" diviſions in our forefield at Haycliff, about eight
" or ten inches aſunder, and a ſeam of white *kebble* ‖
" in the middle of that ſpace, half an inch thick, in
" which the miners rake down a ſharp pointed pick
" until the crackling ceaſes; then they run away,
" knowing that the exploſion will follow in a minute
" or two. Sometimes a noiſe is heard like the beating
" of a church clock, after which the greateſt explo-
" ſions happen.

" I am yours, &c.

To Mr. George Tiſſington, William Mettam."
Winſter.

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‡ *Stemples,* joiſts laid acroſs fiſſures, when the minerals are cut out, by way of making a floor, on which rubbiſh is depoſited, to ſave the expence of raiſing it to the ſurface.

§ *Forefield,* that part of the vein under workmanſhip.

‖ *Kebble,* a white opaque ſpar, calcarious, but not apt to break into rhomboidal forms.

In the above mines the workmen were much alarmed on the firſt of November 1755, about ten in the morning, the time of the earthquake ſo fatal to Liſbon. The rocks which ſurrounded them, were ſo much diſturbed, that ſoil, &c. fell from their joints or fiſſures; and they likewiſe heard violent exploſions, as it were of cannon. Being thus alarmed, they left their ſubterraneous employment, and fled to the ſurface for ſafety. After ſome ſtay there, and no viſible alterations enſuing, their fears began to abate, when they ventured down again, and to their great ſurprize found that nothing material had happened in their abſence. I have related theſe particulars, as ſmall circumſtances ſometimes throw conſiderable lights on phyſical ſubjects.

In ſome of the mines near Winſter, but more eſpecially thoſe at Alport, a mineral ſubſtance is raiſed, known by the name of *black-wad*. It is extremely friable, and when mixed with linſeed oil, as if it were for levigating, it becomes ignited in the ſpace of forty or fifty minutes. Its property of ignition was firſt diſcovered about the year 1750, by the late Mr. Richard Roe, of Derby, who happened to leave a quantity of it upon a levigating ſtone for the ſpace of one hour; and when he returned found the whole heap on fire. Many experiments have lately been made by mixing this mineral with linſeed oil, which produced ſimilar effects. This ſubſtance is much eſteemed by painters for its drying quality. It forms a ſort of *ſtratum*, from one inch to ſeveral feet in thickneſs. The upper part of the *ſtratum* about half an inch thick, is a very fine yellow.

This ſingular ſubſtance has been lately analized with great preciſion, and found to conſiſt of lead, manganeſe, iron, and ſome earth. See Philoſ. Tranſact. vol. 73, part 2d.

Mr. Stone of Alport, a principal proprietor of the above mineral, raiſes it for ſale, on reaſonable terms.

Gypſum, alabaſter, or plaiſter of Paris, is likewiſe a production of Derbyſhire. It is found in a *ſtratum* of marl near Chellaſton, four miles ſouth of Derby. It lies in large irregular nodulous maſſes, differing in colour, being variegated with reddiſh, blue, or greeniſh tints.

It is not laminated, but compoſed of granules like ſugar. Some of it is a fine opaque white, equally as beautiful as ſtatuary marble. It takes a good poliſh, and is much eſteemed as a ſubſtitute for the fineſt marble, in the conſtruction of monuments, and for interior ornamental purpoſes of buildings highly finiſhed, being a durable ſubſtance, and much leſs expenſive to work than marble.

Gypſum, much like the above, is likewiſe found in a *ſtratum* of marl near Newark in Nottinghamſhire, and alſo near Tutbury in Staffordſhire.

Gypsum

The modification of gypſum is very different in different places; for inſtance,

At Clifton near Nottingham, it is perfectly ſtratified, the upper and lower ſurfaces being parallel to each other. This gypſum has alſo a fibrous texture, and its fibres are arranged at right angles between the upper and lower ſurfaces. Several *ſtrata* of this ſpecies of gypſum, may be conveniently obſerved in a cliff near the river Trent, their thickneſs is variable, the greateſt not more than three inches: its colour uniformly white, with ſome degree of tranſparency.

Clifton Gypsum

In various parts of Cheſhire, gypſum is found in marl, laminated and tranſparent. The ſalt ſprings, and ſalt rock, are generally found in this calcarious earth.

Gypsum

The marl *ſtratum* in Cheſhire, containing gypſum, is very thick; I well remember a pit being dug 300 feet deep in that ſubſtance and not cut through. In what manner the plated gypſum is ſtratified I have not been able to obſerve.

Selenites, another ſpecies of gypſum, is found in the iſle of Sheppey, in a *ſtratum* of argillaceous earth, containing nodules of ironſtone and many extraneous bodies. It cryſtallizes in a peculiar form, very different from the above; and it is compoſed of thin tranſparent *laminæ*, ſimilar to talc.

All the various ſpecies of gypſum are applicable to many uſeful purpoſes; namely, as cement to unite ſtone, and particularly the French burs, a ſilicious ſubſtance, more excellent for the purpoſe of grinding corn than any other yet diſcovered. It is likewiſe extremely uſeful as moulds for caſting figures and other ornaments, and alſo as a proper ſubſtance for figures, and the ornaments themſelves. It is alſo much eſteemed for floors and other purpoſes.

Though I have already given ſome account in a former chapter, concerning the formation of minerals; yet it may not be improper to extend thoſe obſervations a little further before we conclude the preſent one.

The mountainous part of Derbyſhire abounds with innumerable inſtances of minerals accumulating on the ſurface of limeſtone, in the fiſſures and cavernous parts thereof: wherein water impregnated with mineral ſubſtances conſtantly exudes, and evaporates, leaving the elementary principles to unite in ſelect bodies according to their affinities, as lead ore, ſpar, fluor, cauk, &c.

Hence it appears, that limeſtone is pervious to water, but by what peculiar operation it becomes thus ſaturated with mineral particles in its paſſage through the limeſtone *ſtrata*, is not within my province to determine; I only take upon me to relate the appearances which have ſo frequently occurred to my obſervation, in thoſe ſubterraneous retreats.

The generation of minerals in Derbyſhire is apparently confined to the limeſtone *ſtrata*: grit, ſhale, toadſtone, or channel, are not productive of minerals.

The above circumſtances ſeem to evince, that the elementary principles which compoſe mineral bodies, are one of the component parts of the limeſtone *ſtrata*, though they are never found in the ſolid ſubſtance of the ſtone.

Hence the limeſtone *ſtrata* in Derbyſhire are conſidered by the miners as the only beds productive of lead ore, though an inſtance or two have happened to the contrary: namely, lead ore in ſhale, in a mine called Shew Engine at Eyam, and copper ore in conſiderable quantities in a mine near Grindon in Staffordſhire, the property of John Sneyd, Eſq. of Belmont.

The above are the only inſtances which have hitherto occurred to me, of minerals being found in ſhale. The argillaceous *ſtrata* therefore can only be conſidered as productive of iron and coal, &c. and not of the ores of copper, lead, or zinc.

But the quantity of minerals thus accumulating, depends much on the quantity of water exuding from the ſurface of the ſtone: for where the quantity of water exuded is ſuperior to the quantity exhaled, the minerals ſuſpended therein do not adhere together, but paſs off with the current in circulation; and leave but little appearance of minerals behind.

Hence ariſe the various effects produced with reſpect to the quantity of minerals generated.

Such are the conſequences ariſing from the circulation of water through the limeſtone *ſtrata* in Derbyſhire. And it is likewiſe evident that the fluids thus in circulation through the limeſtone, become impregnated with a variety of mineral particles at different periods of time, ſince they do not always depoſit the ſame ſubſtance, but form alternate *laminæ* of various minerals, as lead ore, cauk, ſpar, fluor, &c.

The *ſtrata* of toadſtone, or channel, we have already obſerved, is not productive of minerals, though its bladder-holes are generally replete with ſpar; and ſome few inſtances have been diſcovered of ſpar being contained in its fiſſures.

The ſpar thus contained, implies not only a ſolution of ſpar, but alſo that toadſtone is pervious to water thus impregnated, deſcending from the incumbent *ſtrata*: for wherever the toadſtone baſſets, or has no incumbent *ſtratum*, its bladder-holes are totally void of all extraneous ſubſtances, which ſeems to indicate, that the ſpar contained in the bladder-holes of toadſtone proceed from a ſolution of ſpar in the limeſtone *ſtrata* incumbent on toadſtone.

The following operations of nature have lately been obſerved in a mine called Croſs Rake, ſituate in Matlock High Tor, relative to the original formation of *lapis calaminaris*, or the ore of zinc: namely,

I have ſeen many inſtances of dogtooth ſpar being ſo uniformly incruſted by calamine, as to preſerve the true cryſtalline figure of the ſpar.

I have likewiſe ſeen many inſtances of the ſpar thus incruſted, being wholly or only in part decompoſed and replaced by calamine, ſtill retaining the external figure of the ſpar.

Theſe facts manifeſtly imply that the vehicle containing the component parts of the above calamine muſt likewiſe contain ſome acid or diſſolvent principle, whereby the calcarious matter becomes diſſolved; and which ſeems to be the active principle whereby the particles of calamine become detached from the limeſtone which compoſe that mountain.

Hence we may venture to reaſon by the analogy between the veins of calamine in the lordſhip of Cromford, and thoſe in the High Tor at Matlock: for it is obſervable that the former principally abound with calamine, and not with ſpar; and likewiſe that lead ore is frequently incloſed in the calamine. Whence it is preſumed that all ſuch lead ore was originally incloſed in ſpar, the ſubſtance of which is become totally diſſolved,

ved, or decompoſed, as in the inſtance above, and the vacancy replaced by calamine. And we add to the above, that there is a conſiderable analogy with reſpect to the appearance of the two minerals, viz. the calamine in Croſs Rake mine, and that in the mines at Cromford.

Beſide the above, the *ſtrata* in Derbyſhire produce another ſpecies of *lapis calaminaris*, or ore of zinc, but recently known to be the ore of any metallic ſubſtance.

This mineral has been uſually known by the names of black-jack, and mock-ore, from its ſimilitude to lead ore, and from its not being known to contain any metallic ſubſtance whatever. The production, or the generating principles of this ſubſtance, are not accompanied by any diſſolvent menſtrua like the former, being commonly united to a calcarious ſubſtance, conſequently the latter muſt have been originally formed by a different combination of mineral ſubſtances, from that of the former.

I am not inſenſible that the above obſervations, relative to the formation of minerals, will appear very defective in the eyes of a practical chymiſt: therefore I only offer them as ſundry appearances which have occurred in my ſubterraneous reſearches, and leave the cauſe of thoſe effects to gentlemen converſant with ſuch operations of nature.

Many more inſtances might have been added analogous to the former; but I hope the few obſervations which I have ventured to lay before the public, may ſerve to throw ſome light upon a ſubject, which is ſo extremely remote from our inſpection, as the interior parts of the earth: therefore I ſhall only obſerve, that theſe progreſſive operations of nature evidently corroborate the reſult of Chap. IV. for the incruſtation of the dogtooth ſpar is manifeſtly poſterior to that of the ſpar itſelf.

The cryſtals, known by the name of Buxton diamonds, are attended with the following peculiar circumſtances. They are not found in fiſſures, or caverns, of limeſtone *ſtrata*; but in a *ſtratum* of yellowiſh clay, and likewiſe in a *ſtratum* of peat earth; the latter being incumbent on the former. Thoſe found in the clay, are pellucid and colourleſs; but thoſe in the peat earth, have a ſmall tint of red, ſomewhat ſimilar to that of garnets. They are of various magnitudes, from one tenth of an inch in length, to that of five or ſix tenths. They have an hexagonal columnar form, and terminate with an hexagonal pyramid at each end.

Whether all the cryſtals thus found have a ſimilar appearance as to colour, I am not certain; I only mean to ſay that all I have ſeen were ſo circumſtanced.

As peat earth is a congeries of vegetable ſubſtances, which are well known to generate iron; and as the various colours in ſtones are uſually aſcribed to metallic bodies; the facts above related ſeem to corroborate the general opinion concerning the cauſe of coloured ſtones.

As theſe cryſtals terminate with a pyramid at each end of the column, it is evident their formation proceeds from a very different cauſe from thoſe adhering to ſtone, and therefore ſeems to indicate that they were originally formed in the very *ſtrata* wherein they are found.

I have only obſerved them in one particular part of Derbyſhire; namely, in ſome lands belonging to the Duke of Devonſhire, ſituate about two miles ſouth weſt of Buxton; now, or late in the occupation of Mr. Longdon.

I have been informed that cryſtalline bodies are alſo found in the fiſſures of the limeſtone *ſtrata* near Tideſwell, but theſe have only a form repreſenting hexagonal pyramids, the baſes whereof adhere to the limeſtone: hence it appears more probable, that the former were generated in clay and peat earth, as before ſuppoſed.

Rottenſtone being accompanied with ſome ſingular and curious circumſtances, which ſeem to have eſcaped the attention of curious inquirers into natural phenomena; I am induced thereby to ſubmit the following obſervations to the conſideration and candour of the public, as they have ſome tendency to ſhew the mutability of ſubſtances, conſidered as permanently durable. It is found about two miles weſt of Bakewell, in lands belonging to the Duke of Rutland.

Firſt, Rottenſtone is not ſtratified, nor generated in the fiſſures of the limeſtone *ſtrata*, but is found as broken fragments of ſtone, imbeded in vegetable ſoil from the ſurface of the earth to the depth of 18 inches.

Secondly, It is accompanied with numerous nodules of chert, a ſilicious ſubſtance, generated in the limeſtone *ſtrata*.

Chert and rottenſtone being thus blended together, manifeſtly implies the diſſolution of a limeſtone *ſtratum*, in which the chert was originally generated: and likewiſe that the rottenſtone is nothing more than the fragments of limeſtone reduced to a calx.

Such are the appearances relative to rottenſtone, and ſuch the inferences thence deduced; whence it appears that limeſtone is a mutable ſubſtance.

The mutability of limeſtone is likewiſe evident on the tops and ſides of all limeſtone mountains; on the former, innumerable nodules of chert may be obſerved, as well as the broken fragments of thoſe bodies; and particularly on that mountainous tract between Aſhburn and Buxton, where pits have been dug for the repair of public roads.

Chert is obſerved to vary much in its colour, ſome of it being equally as black as the flint formed in chalk, others a lightiſh grey, ſimilar to the colour of the limeſtone.

Many of theſe nodulous maſſes of chert, contain the fiſſures or impreſſions of *entrochi*, or ſcrew-like ſtones; which evidently ſhew that the *entrochi* exiſted anterior to the chert which incloſed them, though the remains of the animals are totally periſhed, and have left no other veſtige behind than the figures or impreſſions of their external and internal forms, as monuments of their paſt exiſtence.

The *entrochi*, or ſcrew-ſtones, which ſo plentifully abound in the Derbyſhire marble, being undoubtedly the remains of an animal not commonly known, though apparently one of the links which connect the animal and vegetable kingdoms; I have endeavoured to collect ſome certain accounts concerning its mode of exiſtence, and likewiſe of the *encrinus*, or *aſteria*, another link which unites the animal and the vegetable kingdoms.

CHAP. XVII.

Of the Encrinus, Aſteria, or Star-fiſh with a jointed Stem. And likewiſe of the Trochites, Entrochi, or Screw-ſtones, which ſo plentifully abound in the Lime-ſtone of Derbyſhire, Staffordſhire, &c.

THE writers on natural hiſtory have been much at a loſs to diſcover to what ſpecies of animal thoſe petrified bodies belonged, which are known to us by the various names of *encrini*, *aſteriæ*, *aſtropodiæ*, ſtar-ſtones, &c. and likewiſe thoſe called *trochites*, *entrochi*, ſcrew-ſtones, St. Cuthbert's beads, &c. which are commonly found in various parts of this kingdom.

Several ſpecies of the former have lately been found, recent, or in a living ſtate, viz. one on the coaſt of Barbadoes, another on the coaſt of Martinico, and a third on the coaſt of Greenland. The firſt explains to what ſpecies of animal thoſe foſſils belong, called ſtar-ſtones, *aſteriæ*, *aſtropodiæ*, &c. the joints or *vertebræ* of the ſtem having a ſimilar form to the *aſteriæ*, or ſtar-ſtones.

Fig. 2. plate VII. repreſents the ſtem, of a recent *encrinus* taken on the coaſt of Barbadoes, with a part of its head, fingers, or claws broken off, and is now in the curious cabinet of the late Dr. William Hunter. Its length is about fourteen inches, and its diameter above one third of an inch, diminiſhing a little toward the top. It is compoſed of pentagonous joints or *vertebræ*, placed regularly one over the other, of a cruſtaceous ſubſtance, and united by thin cartilages, as appears by examining minutely the baſe of the loweſt *vertebræ*, where it is faſtened to the ſtarry indentures of the joint. This makes the ſtem capable of bending at the will of the animal in all directions.

If we examine the five furrows or channels along the ſtem, we ſhall diſcover a ſmall hole between every two *vertebræ*; and in the center of the baſe of the loweſt, where the ſtem is broke, is ſeen a ſmall hole, which probably communicates through the middle of all the *vertebræ* to the cavity in the center of the head.

Along this ſtem at different diſtances, from an inch and a quarter to a quarter of an inch in length, there are many circles of cylindrical jointed arms, five in each round, each ſeries is of equal length, and placed much like the *equiſetum*, or horſetail plant.

Each arm is inſerted into one of the five cavities of the ſtem, and its joints into one another, ſo that the upper end of one joint incloſes the lower end of the next to it with a ſmall margin.

Theſe joints of the arms are generally about one twelfth of an inch in length, and the ſame in diameter; except a few near the inſertion of the ſtem, which are ſhorter and thicker the nearer they are to it.

And here again we may plainly trace a ſmall hole in the arms, paſſing through the midſt of the joints, which communicates through the center of the ſtarry *vertebræ* in the main ſtem, with the hooked joint at the extremity of theſe arms.

On the under or inner ſide of theſe joints, that are near the end of the arms, we may diſcover four minute tubercles in every joint, two at each end; theſe are of the ſame cruſtaceous ſubſtance with the reſt of the joint. By means of this uneven ſurface, together with the hook which the laſt joint forms, bending downward, the animal can take a more ſecure hold of whatever it ſeizes.

But as the ſtem of this animal appears evidently to have been broken off ſhort at the bottom, we muſt remain in doubt whether it moves about in the ſea, or is fixed to rocks and ſhells by a baſe, like corals, ſponges, or *keratophytons*, until ſome further diſcovery ſhall clear up this matter more to our ſatisfaction.

In examining the main ſtem, or column, we may obſerve ſome ſingle joints or *vertebræ* projecting a little further than the reſt: there are generally three or four of theſe in each diviſion. The angular parts of theſe joints end in ſmall round knobs; but the knobs at the corners of the *vertebræ* immediately under the head of the animal, are remarkably larger than the reſt.

The joints or *vertebra* of the ſtem, vary in thickneſs as well as in diameter; the common thickneſs is about one tenth of an inch, but in the laſt four diviſions approaching toward the head, they gradually diminiſh, till they become extremely thin.

We now come to what is called the head, which perhaps may be the body of the animal; for in the center of this dry ſpecimen there ſtill remains a cup of cruſtaceous ſubſtance, and of an oval form, about an inch in length, three quarters of an inch over, and a quarter of an inch deep; in the center of this, as was obſerved before, is a ſmall hole, which apparently communicates with the internal part of the *vertebræ* of the ſtem.

In this cup or cavity, it is probable, were the inteſtines and ſtomach of the animal, as in that kind of *aſteria* called *caput meduſæ*. This cup is ſupported by the baſis of ſix dichotomous teſtaceous arms or branches; perhaps five is the natural number, for one ſeems irregularly

gularly placed. Theſe lower parts or baſes of the branching arms conſiſt of three joints each, and ſurround the cup to which they ſeem united; each of theſe divide into two other jointed branches, that are round or cylindrical on the under ſide, but flattiſh on the upper or exterior ſide, with a deep groove running along the middle, which is furniſhed with two rows of ſuckers. From the upper edges of each alternate joint of theſe branches, ariſe two rows of ſmall jointed claws, like fingers, and theſe two oppoſite rows bend toward each other. Each ſmall branch or finger is about half an inch long, and one twentieth of an inch broad. The ſize of theſe points diminiſh gradually toward the laſt joint, which ends in a point. Each of theſe joints is concave at the lower end, into which is inſerted the convex end of the joint below. With theſe joints, claws, or fingers, they ſecure their prey.

As the finer and more ſubdivided branches, claws, or fingers, were broken off from the head of the recent ſpecimen above deſcribed, I have given the repreſentation of a curious petrified head found at Pryton-paſſage in Glouceſterſhire, in order to convey a more perfect idea of the living animal.

Fig. 1. plate VII. ſhews all the ramified arms of the head cloſed up together.

Fig. 3, 4, 5, repreſent fragments of the ſtem uſually called ſtar-ſtones.

The arms of this animal, which are inſerted into the ſtem, are ſaid to drop off, take root, or fix themſelves to the rocks, where they grow up to full maturity; the uſual mode in which the ſpecies propagate.

The *entrochi*, or ſcrew-ſtones, which ſo plentifully abound in the limeſtone *ſtrata* in Derbyſhire and Staffordſhire, are ſaid to be the remains of a marine animal, of the ſame genus with that above deſcribed, though of a very different ſpecies. Fig. 6. repreſents the head of the ſpecies called *lilium capidium*, with part of its ſtem adhereing, jointed and cylindrical, having a cavity in the central part. Theſe ſtems are ſaid to have been originally cruſtaceous, and united by cartilages like the *vertebræ* of the *encrinus*; and like that animal have been ſurrounded with arms, but not in the ſame order, which drop off from the ſtem, and grow as the former. The arms, together with the fragments of the ſtem, or pedicle, accompany each other in the Derbyſhire marble, and the very ſpots where the inſertions have been made upon the ſtem, are obvious on the leaſt inſpection of the foſſil *entrochi*. Fig. 8. and 9. repreſent two joints or *vertebræ* of the ſtem, uſually called *entrochi*, ſcrew-ſtones, St. Cuthbert's beads, &c. Fig. 6. A, B, is faithfully copied from a petrified animal in the curious cabinet of John Hunter, Eſq. Leiceſter-fields. Fig. 7. G, D, ſhews a continuation of the jointed ſtem as ſuppoſed to be growing, or fixed upon a rock; that being its natural ſituation, it is therefore added to convey a more perfect idea of its hiſtory. The fragments I have frequently obſerved in the Derbyſhire marble, and the various accounts communicated to me from ſeveral gentlemen eminent in that branch of natural hiſtory, corroborate the above conjectures.

They are ſaid to grow, or remain unalterably fixed, upon rocks in the bottom of the ſea; though not any of them have hitherto been found recent, or in a living ſtate, in any part of the world.

The locality of their ſituation ſeems to denominate them one of the links which unite the animal and the vegetable kingdoms in one continued chain of beings.

Among the various marine productions contained in the Derbyſhire *ſtrata*, I have not ſeen any *aſteriæ*; but I have obſerved many of them intermixed with ſoil near Staunton Houſe, in the moſt ſoutherly part of Nottinghamſhire: they are to be found in the ſoil which compoſes the banks of ditches and rivulets; whence it may be inferred, that Staunton was originally their native climate, though they now inhabit the Weſt Indian ſeas.

The preceding accounts relative to the *encrinus* are principally borrowed from the Phil. Tranſ. vol. 52.

CHAP. XVIII.

Of the Strata in North Wales.

THE limeſtone *ſtrata*, of which Holkin mountain is compoſed, are productive of minerals ſimilar to thoſe in Derbyſhire; namely, lead ore, and the ore of zinc, or *lapis calaminaris*. And the argillaceous *ſtrata* at Bagilt, are productive of vegetable impreſſions, viz. of the bamboo, and other ſpecies. And they are likewiſe accompanied with ſeveral *ſtrata* of coal, arranged according to the following table and ſection annexed. See plate V. fig. 2.

Table *of the* Strata *at* Bagilt.

Numb.		Feet.	Inches.
1	Gravel, Sand, *and other adventitious matter*	45	0
2	Shale	9	0
3	Freestone, *argillaceous*	6	0
4	Shale, *though not generally*	1	0

	Numb.		Feet.	Inches.
I	5	Coal	6	0
	6	Clay	9	0
	7	Freestone, *argillaceous*	44	0
II	8	Coal	2	3
	9	Freestone	90	0
	10	Shale	15	0
III	11	Coal	15	0
	12	Clay	12	0
	13	Shale	6	0
	14	Freestone	1	6
	15	Clay, *much indurated*	9	0
	16	Shale	9	0
	17	Blackish Stone, *containing the ſhells of fiſh*	1	0
IIII	18	Coal	9	0
	19	Shale	1	0
	20	Clay, *or* Bind	20	0
	21	Freestone	40	0
V	22	Coal	5	0

Hence it appears that the *ſtrata* at Bagilt, are ſimilar to thoſe accompanying coal in Derbyſhire, Staffordſhire, Shropſhire, Leiceſterſhire, and likewiſe to thoſe in all parts of England hitherto explored.

This general uniformity of *ſtrata* accompanying coal, renders the indications of that ſubſtance the more probable, which is my principal object for giving a ſection thereof, and alſo for inſerting the above table.

In many other parts of North Wales the *ſtrata* are quartzoſe, or whinſtone; a ſubſtance ſimilar to rounded pebbles and bolders, obſerved in the gravel and ſand pits in Cheſhire, and other parts of England, where no ſuch *ſtrata* appear: this circumſtance ſeems to confirm our conjectures concerning the origin of rounded ſtones, ſee page 215, viz. that their forms are owing to attrition, or rolling upon a ſea beach, as will evidently appear by obſerving the effects produced by the fluctuations of the ſea on the Britiſh ſhores, &c.

The ſhells obſerved in *ſtratum* N° 17, evidently ſhew, that the formation of the incumbent *ſtrata*, are more recent than the ſhells, or the *ſtratum* thus covered: therefore a farther teſtimony of the progreſſive operations of nature.

CHAP.

CHAP. XIX.

Obſervations on the Strata in the North of Ireland, particularly on the Giants Cauſeway,

AT Goreſtown in the county of Armagh, two ſhafts were lately ſunk, in hopes of diſcovering a *ſtratum* of coal, but without ſucceſs; I was therefore induced to examine the hillocks, in order to obſerve whether there was any probability of coal in the lower *ſtrata*; and found the ſubſtances which compoſed the hillocks as follow, viz. a lightiſh blue calcarious ſhale, intermixed with marine ſhells, *entrochi*, &c. and likewiſe with ſome nodules of ironſtone, in which were alſo incloſed fragments of ſhells retaining their native teſtaceous matter. The ſhale alſo contained many fragments of limeſtone in which ſea ſhells are inſerted.

Theſe ſingular appearances induced me to conſider the ſhale as a *ſtratum* of decompoſed limeſtone, and therefore unfavourable to the preſence of coal, as having no analogy to the indications of coal in England.

A few days after I viſited Drumglaſs colliery, where I found the *ſtrata* accompanying coal perfectly analogous to thoſe in the Engliſh collieries, viz.

		Feet.	Inches.
1	Clay and Rubble ſtones - -	48	0
2	Soft argillaceous ſtone - - -	30	0
3	Bind, or argillaceous clay - -	35	0
4	Shale - - - - -	15	0
5	Coal - - - - -	4	6
6	Argillaceous ſtone not cut through		
		142	6

Now ſince the *ſtratum* N° 6, is not cut through, it may be neceſſary to obſerve, that there is ſome probability of a *ſtratum* of coal underneath it: therefore it is requiſite to aſcertain the truth thereof experimentally.

In a mountain north eaſt of Moneymore, I obſerved a *ſtratum* of white limeſtone, ſo ſimilar in appearance to a *ſtratum* of chalk, that I had every reaſon to ſuppoſe it a chalk *ſtratum*, fully concreted, or become a perfect limeſtone. I likewiſe obſerved a *ſtratum* ſimilar to the above at Dunlooſe Caſtle, on the north coaſt of Ireland, containing an immenſe quantity of chert, and ſome few marine ſhells of the belemnite kind.

II4

In the vicinity of Maghera, I obſerved many fragments of lavas, and alſo of bluiſh quartzoſe ſtone (called whinſtone) ſcattered plentifully over the lands, but many more of the latter than the former; however the former ſeemed to increaſe in number on the road to Garvah, and ſtill more in the neighbourhood of Coleraine.

Two miles north of that town, on the road to Port-Ruſh-Strand, lies a *ſtratum* of lava: a pit having been dug therein ſeven or eight feet deep, to obtain materials for the purpoſe of repairing the adjacent road, afforded a convenient opportunity of examining the ſeveral phenomena relative to that volcanic matter.

1. The upper part of the *ſtratum* was become totally decompoſed and reduced to vegetable ſoil, though it ſtill contained its original colour, that of a very dark brown.

2. The ſoil was ſucceeded by ſmall fragments of lava, the magnitude whereof increaſed downward to the bottom of the pit, where the *ſtratum* became nearly of one ſolid maſs: an effect commonly produced upon other ſubſtances or kinds of ſtone.

3. This lava contains many bladder-holes, either wholly or in part filled up with zeolite, a ſubſtance rarely found in England.

4. In ſome of the holes which are not completely filled up, may be obſerved the cryſtallized figure of the zeolite, namely cubical, very ſimilar to that of fluor.

5. Theſe cryſtallized bodies likewiſe ſhew, that they were not incloſed in the lava while it was liquid fire, but ſubſequent to that event; having been evidently exuded through the ſubſtance of the lava: conſequently lava ſeems equally as pervious to a ſolution of zeolite, as toadſtone or limeſtone is to a ſolution of mineral ſubſtances.

Zeolite has much the appearance of fluor, both as to colour, figure, tranſparency, and hardneſs. And it has alſo ſomewhat the ſame chymical properties, for it will not efferveſce with acids: but I have been informed by an eminent chymiſt, that it is nevertheleſs ſoluble by acids.

The great analogy between the colour of the ſoil near Coleraine, and the parts adjacent, ſeem to indicate that a vaſt torrent of lava has flowed from the north of Ireland, ſouthward: ſince it may be preſumed, that ſimilar appearances have aroſe from ſimilar cauſes, viz. decompoſed lava. Therefore, ſince the colour extends to the diſtance of twenty or thirty miles toward the ſouth, and nearly as far eaſt and weſt, we may thence infer, what an extenſive track of ground has been covered by liquid fire: namely, twenty or thirty miles from north to ſouth, and nearly as far from weſt toward the eaſt, where it terminates at Balley Caſtle, upon a *ſtratum* of white limeſtone; and at which place the *ſtrata* totally change to different denomination, viz. argillaceous ſtone, clay, and coal. See plate VI. fig. 2. in which the arrangement of the *ſtrata* are repreſented.

Port-Ruſh-Strand exhibits an awful wreck of the terraqueous globe, conſiſting altogether of immenſe maſſes of black lava; ſo extremely replete with bladder holes, and ſo void of extraneous matter, that it perfectly reſembles the *ſcoria* of iron, and therefore leaves not the leaſt doubt of its being a volcanic production.

This ſtupendous cliff is ſituated on the verge of the Atlantic ocean, eight miles north of Coleraine, and four miles weſt of the Giants Cauſeway, Iriſh meaſure, three of which are nearly equal to five Engliſh miles.

The ſame appearances extend toward the weſt; we therefore preſume they are alſo compoſed of ſimilar ſubſtances; and it is eaſy to obſerve a continuation of the lava from Port-Ruſh-Strand, to the Giants Cauſeway, and from thence to Balley Caſtle, a diſtance nearly equal to fifteen Engliſh miles eaſt of Port-Ruſh.

The Giants Cauſeway is ſituated at the foot of a ſtupendous cliff, the elevation whereof is not apparently leſs than five or ſix hundred feet perpendicular above the Atlantic ocean: and yet the whole of this cliff conſiſts of one intire maſs, compoſed of different *ſtrata* of lava; for it is not apparently the effects of one eruption, but of many ſucceſſive convulſions.

The

The ſubſtance of the lava of which that immenſe cliff A, plate VI. fig. 1. is compoſed, is much impaired by length of time, and the uſual operations of the weather; inſomuch that large maſſes thereof become detached daily, and fall into the ſea; whence we may reaſonably infer, that the cliff originally projected much further toward the ſea than at preſent, but to what extent is very uncertain; however, if we conſider the immenſity of time elapſed ſince the cliff was formed, it is not very improbable to ſuppoſe, that it might have extended much further than the baſalt columns now do.

The cliff alſo exhibits many columnar appearances, though very rude and ſhapeleſs, compared to thoſe in the cauſeway, except in a very few inſtances. And as the cliff C, exhibits a ſimilar appearance to that of the cliff A, and as the colour of the intermediate ſoil is likewiſe ſimilar to that of decompoſed lava, we may thence infer a continuation of that ſubſtance from A to C, though ſeveral miles diſtant from each other.

Plate VI. fig. 1. repreſents a tranſverſe ſection of the mountain and the Giants Cauſeway. A the cliff, B the cauſeway.

There are ſome faint traces in the cliff, which ſeem to indicate that the whole of the mountain was not formed by one, but by ſeveral ſucceſſive eruptions, as repreſented in the ſection, and likewiſe, that the columns extend under the cliff toward E, as ſhewn in the plate. Theſe obſervations are only introduced as objects worthy the attention of thoſe, who may be deſirous of exploring the various phenomena relative to theſe magnificent works of nature, and not as matters of fact abſolutely exiſting, but as probable truths.

At the foot of the cliff among the fragments of lava, I found a piece of iron ore, ſimilar in appearance to the Cumberland ore, vitrified on one ſide, which is ſome teſtimony of the cauſe whereby ſome lavas may be magnetical, and likewiſe that the ſubſtances ſuppoſed to be lava, have alſo been in a ſtate of fuſion.

The columns B, E, are in a vertical poſition, and of various diameters, from fifteen to twenty inches, and ſome of them thirty feet long. They ſeem to be all of them priſmatical, or equally thick from end to end, though they conſiſt of various unequal ſided figures, viz. pentagonal, hexagonal, heptagonal, and probably many other forms.

Each column is apparently divided into unequal parts, by means of tranſverſe joints, but many biſect the columns partially, leaving five or ſix inches of the central part ſolid. In ſome inſtances the joints extend quite through the columns, but they have originally

united,

united, and probably ſeparated by water lodging and freezing in them.

The articulations are not flat, but convex and concave, exactly fitted together, but not in any order with reſpect to the convexity or the concavity being upward or downward; for in many inſtances they have been obſerved in both directions.

The columns have one uniform colour, namely, a dark brown approaching toward black, and of one uniform denſity and quality, apparently quite free from bladder-holes, notwithſtanding the cliff is replete with them; therefore ſince it appears that theſe baſalt columns are of one uniform ſubſtance, and have aſſumed a variety of priſmatic appearances, not only in Ireland, but alſo in many other parts of Europe; the preſumption is great, that their various forms are not owing to any property of cryſtallization; ſince it is univerſally allowed, that ſimilar ſubſtances, under ſimilar circumſtances, invariably aſſume ſimilar figures.

Hence it appears that the formation of baſalt muſt ariſe from a different cauſe. But to what cauſe their forms may be owing remains to be aſcertained, and probably may remain a ſecret after every poſſible effort has been made to inveſtigate the true cauſe thereof.

However difficult the problem may appear, let us endeavour to give the beſt ſolution we can, ſince we are not likely to render the ſubject more obſcure by the attempt..

According to the preceding conjectures, the columnar bodies of which the Giants Cauſeway is compoſed, were originally in the very heart of the mountain, and were alſo in a ſtate of fuſion, in which ſtate it ſeems highly probable that they compoſed one uniform maſs of liquid fire, more perfectly fluid than the incumbent *ſcoria*; or perhaps much more ſo than melted iron is to its incumbent droſs.

If the columns were thus in a ſtate of perfect fuſion, and thus protected by *ſcoria* from the external cold, may we not thence infer, that its contraction in cooling from ſuch an immenſe degree of heat, to its preſent temperature, muſt have been very conſiderable, and alſo very gradual. And therefore, ſince ſimilar appearances have been produced from a cauſe ſomewhat ſimilar to the above, namely, a contraction from wet to dry, as in the inſtance of the *ludus helmontii*; we may thence infer by analogy, that baſalt columns were formed by contraction, from an extreme degree of heat to that of their preſent temperature. However, ſuch are the conjectures which have hitherto occurred to me concerning the origin of baſaltes.

Among the many curious and intereſting obſervations communicated to the world by that ingenious mineralogiſt,

logiſt, Mr. E. Raſpe, on the ſubject of extinguiſhed volcanos, it appears that baſalt is commonly found in the vicinity of them, which is a conſiderable teſtimony of its being a volcanic production.

And the learned naturaliſt M. Faujas, has likewiſe favoured the public with an excellent treatiſe on the ſame ſubject, containing many inſtances of baſaltes being abſolutely a part of the matter which flowed from a volcano in a ſtate of liquid fire, which evidently appear, from the ſame maſs of lava ſituated near its crater, being wholly and in part columnar. This learned gentleman likewiſe obſerves, that in ſome of the correſponding faces of theſe priſmatic columns, are inſerted fragments of granite, which were evidently broken and ſeparated by the contraction of the lava in cooling, a portion of the granite remaining in each of the correſponding faces.

A little obſervation, ſays the author, on the cauſeway at Bridon Bridge, will ſatisfy the moſt inquiſitive naturaliſt, that the priſmatic columns which compoſe it, are placed in a vertical poſition, and in the fineſt order, and are ſeparated from each other by interſtices about five or ſix lines, or half an inch in width. And it is eaſy to obſerve that the lava of which this cauſeway is compoſed, has not been removed by any accidental cauſe, but remains where it was originally depoſited:

therefore no one can aſcribe the disjunction of theſe columnar bodies to any other cauſe but that of contraction by cooling.

M. Faujas likewiſe obſerves, that theſe priſmatic columns have a diverſity of figures, viz. triangular, quadrangular, pentangular, hexangular, heptangular, and octangular.

Conſequently this great variety of figures is a further teſtimony that their columnar forms are not owing to cryſtallization.

That baſaltes is lava, is alſo evident from the obſervations of the Rev. Dr. Troil, in his tour through Iceland: for this great iſland is allowed to be compoſed principally of lava, and yet various parts thereof plentifully abound with baſalt columns of various figures and dimenſions.

After ſo many corroborating teſtimonies tending to prove the origin of baſaltes, nothing more is requiſite to aſcertain the fact, but that of being an eyewitneſs to the operation itſelf; yet as the ſubject has been ſo much controverted, it may not be improper to add the obſervations of Mr. Hodges, in his late tour through India, in the line of his profeſſion: viz. That a cliff called Moutagena, is wholly compoſed of baſaltes; and that under the cliff, is a ſpacious extenſive cavern, which he thoroughly examined by the aid of torches, and obſerved the ſame columnar appearances as on the exterior parts thereof, and likewiſe that charcoal was imbeded in the ſolid ſubſtance of the ſtone throughout the whole extent of the cavern.

The ſingular appearances accompanying the above columnar bodies, with reſpect to charcoal being imbeded in the ſolid ſubſtance of the ſtone, ſeems to have been an effect produced at a time while that matter was liquid fire. That circumſtance being duly conſidered, together with the durability of charcoal, leaves little room to doubt the origin of the ſubſtance in which the charcoal, or burnt wood is incloſed.

But notwithſtanding the preceding obſervations have ſome tendency to unfold the original cauſe of baſaltes, ſome doubts may nevertheleſs ariſe, with reſpect to the origin of the Giants Cauſeway, and its adjacent mountain, ſince no viſible crater, nor the leaſt veſtige of an extinguiſhed volcano, are now remaining, except the ſubſtances before mentioned, from whence ſuch immenſe torrents could have flowed, as are now ſpread over ſo great a part of the north of Ireland.

Theſe circumſtances render it neceſſary to obſerve, that whoever attentively views and conſiders theſe romantic cliffs, together with the exterior appearances of that mountainous cliff, will I preſume ſoon diſcover ſufficient cauſe to conclude, that the crater from whence that melted matter flowed, together with an immenſe track of land toward the north, have been abſolutely ſunk and ſwallowed up into the earth, at ſome remote period of time, and became the bottom of the Atlantic ocean. A period indeed much beyond the reach of any hiſtorical monument, or even of tradition itſelf.

But though it does not appear, that any human teſtimony, or record, has been handed down to us concerning ſuch a tremendous event; yet the hiſtory of that fatal cataſtrophe is faithfully recorded in the book of nature, and in language and characters equally intelligible to all nations; therefore will not admit of a miſinterpretation; I mean thoſe ſtupendous cliffs which environ a part of the Atlantic ocean.

Theſe are characters which cannot miſlead, or divert our attention from the true cauſe thereof; and we may further add, as a collateral teſtimony, that ſubterraneous fires have frequently burſt open the bottom of that ocean in various parts, and have formed new iſlands of conſiderable magnitude: whence it is evident that the ſame cauſe ſtill exiſts, and produces ſimilar effects. I ſay, the conſideration of ſuch diſaſters, together with that of the cauſe ſtill ſubſiſting under the bottom of that immenſe ocean, almoſt perſuade me to conclude that Ireland was originally a part of the iſland Atlantis, which, according to Plato's Timæus, was totally ſwallowed up by a prodigious earthquake, in the ſpace of one day and night, with all its inhabitants, and a numerous hoſt of warlike people, who had ſubdued a great part of the known world.

The hiſtory whereof is quoted by Dr. Hooke, in his Poſthumous Work, to the following purport; viz. Solan being at Saim in Egypt, when Amaſis was king, inquired of thoſe prieſts who were moſt converſant with hiſtory, what they knew concerning the antiquity of Greece, or Athens, and was anſwered by one of the ſenior prieſts, as follows:

Many wonderful actions of your city are recorded in our monuments, but particularly one for greatneſs and virtue exceeds all the reſt; namely, that both Greece and Egypt were invaded by a numerous army of warlike people from the iſland Atlantis: an immenſe iſland, ſituate where the Atlantic ocean now flows, and governed by ſeveral powerful kings, who not only ruled over the whole of that iſland, but ſeveral others, and likewiſe over a great part of the continent. The united force of theſe kings invaded both Greece and Egypt, and were bravely repulſed and driven to their native iſland, which, immediately after their return was totally ſwallowed up into the bowels of the earth, with all its numerous inhabitants, in one day and night, by a prodigious earthquake and inundation of water. See Dr. Hooke's Poſt. Work, p. 373.

Such is the ſubſtance of the hiſtory related by Plato, and quoted by Dr. Hooke. But whether ſuch an iſland as Atlantis ever exiſted, and was thus overwhelmed, may ſtill remain doubtful, though ſimilar events, but of leſs magnitude, have frequently happened in various parts of the world; therefore ſince ſuch events are not repugnant to the operations of nature, it is not improbable but the preceding obſervations, and alſo the Platonic hiſtory, may have ſome foundation in nature. But theſe remarks are rather a digreſſion from the ſubject; therefore to return.

I have already obſerved that the lava extends from Port-Ruſh-Strand, to the Giants Cauſeway, and from thence to Balley Caſtle, where it finally terminates upon a *ſtratum* of white limeſtone, and where a new arrangement of *ſtrata* commences, quite of a contrary nature, as repreſented in plate VI, fig. 2. B, the lava, L, the white limeſtone.

Two miles eaſt of Balley Caſtle, the following *ſtrata* commence. See plate V.

1 Whinstone, *a quartzoſe ſubſtance, which ſtrikes fire with ſteel.*
2 Firestone, *argillaceous*
3 Till, Shale, *or laminated clay*
4 Stone, *argillaceous*
5 Till, *or* Shale
6 Freestone, *argillaceous*
7 Coal, *four feet ſix inches thick*
8 Stone, *argillaceous*
9 Till, *or* Shale
10 Limestone, *brown, containing no marine ſhells*
11 Bind, *indurated clay*
12 Stone, *argillaceous*
13 Strata, *not aſcertained*
14 Millstone Grit, *containing quartz pebbles.* This *ſtratum* is perfectly ſimilar to *ſtratum* N° 1, in the Derbyſhire ſections.

Plate V, fig. 1. repreſents a tranſverſe ſection of the mountain; L L, a drift or road into the mountain, for the purpoſe of conveying coal to the wharf.

The ſections plate V and VI, are particularly recommended to the reader's conſideration, as matters of ſome importance tending to the diſcovery of coal.

The ſection plate VI, fig. 2. affords a convenient opportunity of comparing the lava and whinſtone, which in ſome few inſtances are ſo ſimilar as to render them not eaſily diſtinguiſhable from each other.

The arrangement of the *ſtrata* two miles eaſt of Balley Caſtle, is in part obtained from my own obſervations, and in part from ſeveral experienced workmen, employed in raiſing ſtone from the above *ſtrata*, which is of a tolerable good quality and colour, fit for buildings, and conveniently ſituated for water carriage.

The *ſtratum* N° 14, is totally covered by the ſea at highwater; it is ſituated below the quarries, and requires ſome attention to diſcover it.

Here it may be neceſſary to obſerve, that as the above *ſtratum* of whinſtone incumbent on coal is the only inſtance of the kind which has hitherto occurred in the courſe of my obſervations, it may ſerve to ſhew, the neceſſity of aſcertaining the arrangement of the *ſtrata* in many parts of the world, in order to obtain a more competent knowledge of the general conſtruction of the earth. For if I had not previouſly obſerved a *ſtratum* of whinſtone ſituated as above deſcribed, I ſhould not have conſidered that ſtone to have been arranged with the coal *ſtrata* in any part of the world: therefore let it be remembered, that in ſubjects of ſubterraneous geography we can only reaſon by the analogy which one part of nature bears to another.

But having once obſerved a notorious inſtance of whinſtone being incumbent on coal in one part of Ireland, we may thence infer, that it may likewiſe be incumbent on coal in other parts of that kingdom; but more eſpecially ſo, in the vicinity of the colliery before deſcribed: for ſuch is the regularity in the arrangement of the *ſtrata*, that coal certainly lies beneath the whinſtone, and all the other beds of ſtone and clay in that neighbourhood.

But notwithſtanding whinſtone may be conſidered as a certain indication of coal in the county of Antrim, yet it is not to be underſtood that it is univerſally incumbent on coal, in every other part of Ireland: for, according to the general appearances on the ſurface of the earth, the *ſtrata* thereof ſeem to have been thrown into as much diſorder by ſubterraneous convulſions, as the *ſtrata* in England. And therefore, by parity of reaſon, it may be inferred that ſimilar effects have been produced in the former as have taken place in the latter.

Therefore, ſince there are many notorious inſtances in Derbyſhire, wherein the upper *ſtrata* have diſappeared, as before deſcribed; ſo in like manner the upper *ſtrata* in Ireland may likewiſe have been removed by a ſimilar cauſe.

Therefore it becomes eſſentially neceſſary to know the appearances of all the *ſtrata* beneath the whinſtone; ſince that *ſtratum* may be totally removed, and the others, or at leaſt a part of them remain; any one of which become as certainly an indication of coal, as if the whole arrangement was complete, as repreſented in the ſections plate V, or VI. The obſervations given of the Derbyſhire *ſtrata*, may render any further account of theſe matters unneceſſary; therefore I ſhall only obſerve, that ſpecimens of each *ſtratum* of ſtone, clay, &c. numbered according to the above arrangement, or in the order they lie in the earth, will be an infallible guide in ſuch reſearches; and it is alſo required to record the thickneſs of each *ſtratum*; for by that means the depth of the coal may be truly aſcertained.

And it may be convenient further to obſerve, that as the *ſtrata* in Ireland have been apparently thrown into as much confuſion as thoſe in England and Wales, it ſeems highly probable that the former may baſſet, or appear near the ſurface of the earth, as well as thoſe in the latter: therefore, by exploring the cliffs, both coal and minerals, or the indications thereof, may be obſerved ſo as to facilitate the diſcovery of thoſe ſubſtances.

And let it be remembered, that the impreſſions of vegetables in ſtone or clay is a particular indication of coal in the lower *ſtrata*.

With reſpect to minerals, no ſuch rules are ſtrictly to be regarded; for experience ſhews that they are produced in *ſtrata* of different denominations: namely, in Derbyſhire and Staffordſhire, lead and copper ores are generally produced in the fiſſures, and between the *lamina* of the limeſtone *ſtrata*. And we have one ſingular inſtance of copper ore being found in a *ſtratum* of ſhale near Leek, in a mine belonging to John Sneyde, Eſq. But ſhale is not to be conſidered in any degree as productive of minerals.

At Kady in the county of Armagh, a tolerable vein of lead ore has been diſcovered in a *ſtratum* of whinſtone; but the quantity of water flowing into the mine renders the work of little value.

Here it may be convenient to obſerve, that ſince whinſtone is incumbent on coal at Balley Caſtle, it may probably be ſo too at Kady, and elſewhere.

Among the numerous phenomena exhibited in various parts of Ireland, I preſume there are but few more conſpicuous, or more inſtructive, in matters relative to the antiquity of arts, and the ſtate of civilization in that country, than the following.

Firſt, Ireland plentifully abounds with peat grounds of conſiderable depth, a ſubſtance well known to ariſe from a luxuriant vegetation, and from no other cauſe.

Secondly, Theſe peat grounds are plentifully ſtored with foſſil wood; namely, large and ſmall trees, retaining their fibrous roots; and theſe trees lie in every poſſible direction, as if they had floated in water, and been left as above deſcribed: for their fibrous roots and their ſituations evidently ſhew that they never grew in the earth which now incloſes them. Thus are the generality of peat grounds circumſtanced, both in England and Ireland.

Thirdly, I have been informed that there are ſeveral inſtances where the bog earth and the foſſil wood have been totally cut up, and cleared from off the ground upon which the bog originally began to accumulate; and that the land ſo cleared was obſerved to lie in ridge and furrow: whence we may infer, that theſe lands were actually ploughed prior to the wood being laid thereon; for the form of the ground cannot be aſcribed to any other cauſe but that of ploughing.

If the above phenomena are granted as matters of fact, the following queſtion will probably ariſe: namely, by what means was the wood thus ſcattered over the arable lands? To which we reply, not by the hands of men, nor by a tempeſt, but by a vaſt deluge of water, which probably overflowed the greateſt part of Europe; ſince ſimilar inſtances are very common in various parts of England, of which I have frequently been an eyewitneſs.

But it is not ploughed grounds alone which indicate a ſtate of civilization and arts, prior to that event; remains of arts have alſo been diſcovered by the above means, namely, fire-hearths, fences, and the remains of buildings.

And in the year 1692, as ſome workmen were cutting peat earth for fuel in Tipperary, ten feet below the ſurface they found a cap or crown of gold, weighing five ounces, curiouſly wrought. See Archæologia, vol. 7. p. 103.

The ploughed grounds, fire-hearths, fences, &c. evidently ſhew that all ſuch places were originally the ſurface of the earth; and the quantity of peat earth accumulated thereon, manifeſtly implies that the kingdom of Ireland was totally depopulated, and remained deſolate a conſiderable ſpace of time, previous to its being inhabited again. For it ſeems reaſonable to ſuppoſe, that if the owners, or the occupiers of the lands, thus covered by wood, had ſurvived the cauſe of that event, they would rather have preferred the removal of the wood from their ploughed lands, than that of clearing uncultivated lands of growing wood, for the purpoſe of tillage: therefore, ſince ſo much wood was ſuffered to remain upon cultivated lands, we may thence infer, that neither the owners nor the occupiers thereof ſurvived the dreadful cataſtrophe.

Whether this great revolution can with more propriety be attributed to the deluge of Noah, or Ducalion, is not a matter of much importance; that it was occaſioned by an immenſe flood is very evident, from the effects produced; ſince no other cauſe in nature, yet known, could have ſeparated trees from the earth with all their fibrous roots, and have aſſembled them together in the order above deſcribed.

And theſe conjectures are rendered the more probable, when we conſider the vaſt quantities of lava on the north coaſt of Ireland; for the former and the latter ariſe from one and the ſame cauſe, as already obſerved, Chap. XII.

But the above are not the only marks of deſolation occaſioned by that tremendous convulſion; for the remains of the mooſe-deer, and other animals, which are ſo frequently found at the bottom of the peat earth, may likewiſe be conſidered as victims of the ſame cauſe.

Therefore, from all the various circumſtances relative to the preſent ſtate of Ireland, we may infer, that arts and civilization had made a conſiderable progreſs in that kingdom prior to the above tremendous event; that it was totally depopulated. and remained quite deſolate very many centuries before it was repeopled: for it is well known that peat earth is generated from vegetable matter, and that the branches of trees lying upon the earth occaſion a luxuriant vegetation, and eſpecially in places ſavourable to retain ſome water: hence we preſume that peat earth was originally generated by means of wood thus aſſembled together, and remaining undiſturbed on the ſurface of the earth many hundreds, or perhaps thouſands of years. Thus in proceſs of time the conſtant accumulation of vegetable ſubſtances of various kinds were formed into peat earth, and became an excellent fuel: and the immenſe quantity of fir timber entombed in the peat earth, ſeems to have contributed a conſiderable quantity of bituminous matter to the generality of that ſubſtance.

Hence peat earth, containing foſſil wood, circumſtanced as above deſcribed, may be conſidered as ſome certain teſtimony of the great revolutions which the earth has undergone, and probably at different periods of time. Therefore it is not Ireland alone which exhibits evident marks of devaſtation on the ſurface of the earth, but Great Britain likewiſe; for many parts of this kingdom abound with foſſil wood, and particularly Cheſhire, Lancaſhire, and Yorkſhire. For inſtance:

Twelve miles below York, at Youle, ploughed lands have been diſcovered under the following *ſtrata*,

1 Rich firm ſoil
2 Sand
3 Boggy earth, containing foſſil wood.

Under the peat earth the ground was firm, and lying ridge and furrow. Lowthorp's Abridg. vol. 2, p. 424.

And I have been informed that lands have been diſcovered in the ſame ſtate, under a part of Tatmoſs in Lancaſhire, which was cut away for fuel.

Much foſſil wood is alſo found in peat earth near Congleton in Cheſhire, attended with the following remarkable circumſtances, viz.

The trunks of trees are generally ſeparated from the roots, as it were, juſt above the ſurface of the earth, but by what means does not altogether appear; though in ſome inſtances fire has evidently been the cauſe. And the roots and the trees thus ſeparated, are aſſembled together in as much confuſion as poſſible, that is to ſay, the roots, with all their fibrous parts, lie upon the trees as often as the trees lie upon the roots; in ſhort, they are ſo confuſedly laid together, that nothing leſs than a vaſt flood of waters would have produced ſuch an effect of ſeparating them from the earth, and throwing them into ſuch heaps of confuſion.

The roots and the trees are ſo generally found as above, that the former have acquired the appellation of crowns.

Though the above trees are ſuppoſed to have been thus aſſembled together, the elevation of the ground cannot be leſs than one hundred feet above the level of the adjacent rivers.

Some few remains of arts and civilization have alſo been diſcovered in the great continent of North America, which ſeem to ſhew that great revolutions have happened in that part of the world, whereby not only the inhabitants thereof, but their reſpective arts, have been almoſt totally deſtroyed; as if no ſuch people, or their arts, had ever exiſted. For inſtance:

I have been informed, by the very beſt authority, that two wells have been diſcovered walled round with brick, according to the European method.

And likewiſe that a plough has been found ſixty feet deep, by ſinking a well for water.

And we have had a recent inſtance of many coins being found beneath a large ſtone at Miſtick, about four miles from Boſton; one of which was lately preſented to the Antiquarian Society. The coins are round, and lettered on both ſides, but whether in Turkiſh, Arabian, or Phenician characters, remains to be aſcertained; ſo various are the opinions concerning them.

From the above circumſtances it ſeems reaſonable to conclude, that bricks were in uſe prior to the Europeans ſettling upon the continent; and that, as bricks were unknown to the native Indians, they muſt have been applied by a people antecedent to them, with whom arts and civilization had been cultivated to a conſiderable degree. Whence it is preſumed, that thoſe very people, and their arts, have both periſhed by means of a dreadful revolution in the natural world: of which the plough is another inconteſtable evidence; for it would be abſurd to ſuppoſe it was buried ſixty feet deep by the hand of man.

Why have recom to revolution see page 265 —

The above inſtances may therefore be conſidered as marks of art and civilization having made a conſiderable progreſs in North America, at ſome very remote period of time.

With reſpect to the coins, we cannot ſpeak of them with equal certainty, as the works of that country, though there is ſome probability of their being of conſiderable antiquity.

The great aſſemblage of bones diſcovered upon the banks of the river Ohio, have been aſcribed, with much reaſon, to the effects of a deluge of water gradually riſing, from which the animals fled for ſafety into a ſmall ſpot of ground; but the waters increaſing upon them, reduced the larger animals to the neceſſity of trampling down the ſmaller for their own preſervation. But after every poſſible effort to preſerve their own lives, the largeſt and the moſt powerful of them periſhed with the ſmaller and weaker animals: for the heap of bones is thus circumſtanced, the bottom thereof is compoſed of the ſmaller, and the upper part of the largeſt and moſt powerful animals.

The greateſt part of a jaw-bone, belonging to one of the largeſt of thoſe creatures, containing one of its grinders, or largeſt teeth, is preſerved in the Britiſh Muſeum for the inſpection of the curious.

The form of this enormous bone is ſomewhat analogous to thoſe of the ox or horſe; its dimenſions as follow, viz. from the top of the condyle to the anterior extremity of the bone in a ſtraight line, thirty-five inches; the baſe alone in a ſtraight line, twenty-eight inches. A carnivorous animal, longer than the ordinary elephant.

The preceding obſervations leave little room to doubt the great antiquity of arts and civilization in England, Ireland, and North America; and at the ſame time plainly evince, that thoſe parts of the world have ſuffered great devaſtations from natural cauſes: therefore to ſuch fatal events, and to the conqueſts of civilized nations by ſavage barbarians, we may venture to aſcribe the ſubverſion of arts and ſciences at ſundry periods of time.

Hence we preſume that the preceding deductions may throw ſome conſiderable light upon the conjectures of Lord Bacon and other eminent philoſophers, relative to the fragments of ancient learning and philoſophy, ſuppoſed to have been handed down to the Phenicians and Egyptians, from the memorials of more ancient nations, concerning the primitive ſtate of the earth, and from them to the preſent age.

The concurrence of ſacred and profane hiſtory in theſe obſtruſe ſubjects, and alſo with the reſult of the preceding inquiries, flatters me with the hopes that theſe reaſonings have ſome foundation in nature and truth.

Therefore, to conclude: if the few obſervations I have made, or the inferences thence deduced, ſhould prove inſtrumental in throwing any light upon *ancient hiſtory, ſacred or profane*; or contribute in any degree to the entertainment of ſpeculative minds, or to the more ſolid purpoſes of human life, my labours will be abundantly gratified.

RECAPITULATION.

PRESUMING that a conciſe account of the preceding work may be acceptable to ſome of my readers, I have endeavoured to bring the ſeveral parts thereof into a nearer point of view, in order to render their relations and dependencies upon each other the more obvious.

The terraqueous globe which we now inhabit was originally in a ſtate of fluidity; and that, *not owing to any diſſolvent principle, or ſubſequent ſolution, but to the firſt aſſemblage of its component parts.* Whence it is preſumed, *that the earth had a beginning, and has not exiſted from eternity*, as ſome people have imagined; although the ſagacity of man has not hitherto been able to aſcertain, with any tolerable degree of preciſion, the number of ages elapſed ſince its component parts were firſt aſſembled together by the univerſal law of gravitation.

We therefore leave the antiquity of the earth to the conſideration of future ages, and confine our reſearches only to unfold its original ſtate and formation, and the changes it has undergone.

The fluidity of the earth, and the infinite diviſibility of matter evidently ſhew, that the component parts of *air*, *earth*, *water*, &c. were uniformly blended together, none being heavier or lighter than another; whereby they compoſed an uniform maſs or pulp, of equal conſiſtence and ſameneſs in every part, from its ſurface to its center; conſequently, the new-formed globe was totally unfit for animal, or vegetable life; and therefore it would ſeem extremely abſurd to ſuppoſe, that either the former or the latter were created during the chaotic ſtate of the earth, or prior to its being formed into a habitable world: therefore, the preſumption is great, that mankind were not created till the earth was become ſuitable to the nature of their exiſtence. Whence it appears that the ideas which were ſo ſtrongly impreſſed on the minds of the Phenicians and Egyptians, could not poſſibly have been derived from obſervation, but from the *laws of gravity*, *fluidity*, *and centrifugal force*; *and more eſpecially ſince there are no other laws or principles in nature yet known*, *from whence the chaotic ſtate of the earth could have been deduced.*

May we not therefore conclude, that the Newtonian philoſophy, was not only known, but applied to the inveſtigation of phyſical ſubjects anterior to the Phenician or Egyptian nations. Since thoſe people have only aſſerted the reſult of phyſical reaſonings, and have either withheld, or were ignorant of the original deductions; the latter being the moſt probable, we may thence infer, that the doctrines which they advanced, were no other than the ſcraps of ancient learning, borrowed from the memorials of more ancient nations, and were then become by length of time, nothing more than the prevailing opinion of the ages wherein thoſe people lived. Theſe circumſtances, being duly conſidered, ſeem to indicate many and great revolutions both in the moral and the natural world; the latter produced by means of ſubterraneous convulſions, and the former by the conqueſts of civilized nations by ſavage barbarians, many of which events are recorded in ſacred and profane hiſtory.

May we not therefore conclude, that arts and ſciences were arrived to a conſiderable degree of perfection in very early ages of the world; and that by ſundry occurrences they have been repeatedly deſtroyed, and again revived, as if no ſuch people, arts, or ſciences, had ever exiſted.

To return: The component parts of the chaos were heterogeneous, or endued with peculiar *laws of elective attraction*, whereby ſimilar ſubſtances are diſpoſed to unite and form ſelect bodies of various denominations, as *air*, *water*, *earth*, &c. by means of theſe principles, the chaos was progreſſively formed into a habitable world.

But the firſt operation of nature which preſents itſelf to our conſideration, is the oblate ſpheroidical figure of the earth, acquired from its diurnal rotation, and the laws of gravity, fluidity, and centrifugal force; which was no ſooner completed, than the component parts began to act more freely according to their affinities; hence the particles of air united to thoſe of air, thoſe of water to water, and thoſe of earth to earth; and with their union commenced their ſpecific gravities, which deſtroyed the uniform ſuſpenſion that had hitherto prevailed throughout the whole of the chaotic maſs.

Thus commenced the ſeparation of the component parts; for thoſe of the greateſt denſity, began their approach toward the center of gravity; and thoſe of the greateſt levity, aſcended toward the ſurface; therefore as the ſpecific gravity of air is nearly 800 times lighter than water, the preſumption is great, that the former was ſooner freed from the general maſs than the latter, and formed a muddy impure atmoſphere, ſurrounding the newly formed globe: water being next in levity, ſucceeded the air, and univerſally encompaſſed the earth in one vaſt ocean. In proceſs of time theſe elements became perfectly pure, and fit for animal life.

The component parts of the chaos being thus *progreſſively* ſeparated and formed into ſelect bodies, the following conſequences neceſſarily enſued; namely, as the ſun and the moon were coeval with the chaos, the ſolids could not uniformly ſubſide from every part of the ſurface, and become equally covered by water: for as the ſeparation of the ſolids and fluids increaſed, ſo in like manner the tides increaſed, and removed the former from place to place without any order or regularity. Hence the ſea became unequally deep, and thoſe inequalities daily increaſing, in proceſs of time dry land appeared, and divided the waters, which had hitherto prevailed univerſally over the earth. The primitive iſlands being thus formed, in proceſs of time they became firm and dry, and fit for the reception of the animal and vegetable kingdoms.

Such appears to have been the natural order and progreſſion of theſe things; conſequently, as the ſun was coeval with the earth, ſeveral days and nights preceded the ſun's firſt appearance in the heavens, or its becoming viſible on the fourth day, according to the ſcripture account.

Here it may be convenient to obſerve, that as the ſeparation of the chaos proceeded from the union of ſimilar particles, and likewiſe that reſt is favourable to ſuch operations of nature, we have thence inferred, that as the central parts of the earth were more immediately quieſcent than thoſe remote from the center, it may be preſumed that the former began to conſolidate before the latter; therefore it would be repugnant to the laws of nature to ſuppoſe, that the central part ſhould conſiſt of water only, and the more ſuperficial part thereof, of a ſhell or cruſt, as ſome writers have imagined.

The atmoſphere, ſea, and land, being thus formed for the reception of the animal and vegetable kingdoms in ſucceſſive periods of time, we have now to conſider the order in which they were ſeverally created. Firſt, ſince it appears that the ocean became perfectly pure and fit for animal life before the primitive iſlands were formed; therefore we have endeavoured to prove from a ſeries of undeniable facts, that marine animals were firſt created, and being extremely prolific, they increaſed and multiplied ſo exceedingly, as to repleniſh the ſea from pole to pole. The ocean being thus ſtocked with inhabitants, prior to the formation of the primitive iſlands, many of them became enveloped, and buried in the mud, by the continual action of the tides; particularly all ſpecies of ſhell fiſh, which were the leaſt able to defend themſelves from ſuch interments. Therefore, ſince the remains of marine animals are imbeded at various depths in the earth, from one to that of ſeveral thouſands of feet, and this in all parts of the world hitherto explored, they bear ſufficient teſtimony that theſe marine bodies were thus entombed at ſucceſſive periods of time, and likewiſe that they were created prior to the primitive iſlands, and conſequently prior to any terreſtrial animals: therefore, the reſult of this reaſoning is another inſtance of the agreement between revelation and reaſon.

It may be needleſs further to obſerve, that theſe beds of marine ſhells plainly evince that they were generated, lived, and died in the very beds wherein they are found, and were not brought from diſtant regions by a flood, or floods of water, as ſome people have ſuppoſed: conſequently ſuch beds were originally the bottom of the ocean. Theſe phenomena therefore evidently corroborate the concluſions we have drawn, Chap. V, VI, and XII. with reſpect to the ocean prevailing univerſally over the earth, the formation of the primitive iſlands, and the bottom of the ocean being elevated by the expanſive force of ſubterraneous fire, and formed into mountains, continents, &c. whereby the concentric arrangement of the *ſtrata* was totally deſtroyed, and they were thrown into heaps of ruins. The earth being thus metamorphoſed, was productive of great extremes of heat and cold: for it evidently appears from actual obſervations on the temperature of the air in various parts of the world, that the great extremes of heat and cold, in the torrid and frigid zones, are not altogether owing to their reſpective ſituations on the globe, but principally to thoſe vaſt tracts of lands, the continents: therefore, ſince the extremes of heat and cold commenced with the production of mountains and continents at the time of the deluge, the preſumption is great, that the temperature of the air and ſeaſons in the antediluvian world, were ſo conſtantly uniform and mild, that froſt and ſnow had no exiſtence on the face of the earth from pole to pole. And this reaſoning is abundantly confirmed by the numerous remains of marine animals imbeded in the earth, remote from their native climates; and likewiſe from the longevity of the antediluvians, which, according to revelation and reaſon, ſuffered little or no alteration from Adam to Noah; the former having lived to the age of 930, and the latter to that of 950. And as a farther teſtimony of the great change in the conſtitution of nature, we may inſtance the firſt appearance of the rainbow, ſubſequent, and not prior to the deluge, which was evidently an effect of the ſame cauſe.

And we may likewiſe add, as a corroborating cauſe thereof, that the period of human life, gradually contracted from the deluge to the days of Terah, to that of 200 years. And the longevity of Jacob's numerous family ſeems to ſhew, that about 120 years was the ordinary age of mankind, ſince his children were the offspring of ſundry wives and concubines; for his ſon Joſeph attained to the age of 110 years, and Levi to 137.

Now, from all the various circumſtances relative to the ſtate of nature before and after the flood, we have every reaſon to conclude, that the antediluvians lived to the amazing age of many hundred years, as recorded in the ſcriptural account; and likewiſe that the ſpontaneous products of the earth before the flood, were more than ſufficed the calls of human nature without art or labour. A time, when the burning heats of ſummer, and the ſeverities of winter's cold, were not come forth; but ſpring and autumn reigned together, and the trees were continually loaded with bloſſom and fruit. Hence no need of any other protection from the inclemency of the ſeaſons, nor of barns for winter's ſtore, than the benevolent Author of nature had plentifully provided for them. Conſequently in a ſtate of nature like this, there was no temptation to acts of violence, injuſtice, fraud, &c. every one having plenty and enough, each equally partook of the numerous bleſſings thus amply provided for him. Power and property being equally diffuſed, men lived together in perfect peace and harmony, without law, and without fear; therefore it may be truly ſaid of the antediluvians, that they ſlept away their time in ſweet repoſe on the ever verdant turf. Such apparently was the ſtate of nature in the firſt ages of the world, or from the creation to the firſt convulſion in nature, whereby the world was not only univerſally deluged, but reduced to a heap of ruins. At that dreadful era, and not before, the year became divided into ſummer and winter, ſpring and autumn, and the ſpontaneous products of the earth no longer ſufficed the calls of human nature without art and labour: wherefore he who ſowed would expect to reap, and he who built a hut for his protection, would naturally expect to enjoy the fruits of his own labour: neceſſity therefore was the parent of property, and property created a thouſand imaginary wants, which its poſſeſſors endeavoured to gratify, and their example excited ſimilar ideas in thoſe who had it not, but nevertheleſs ſtudiouſly endeavoured to gratify their artificial wants by unjuſtifiable means: hence the neceſſity of laws, dominion, and ſubordination, which had no exiſtence in the antediluvian world.

To that great revolution in the natural world, we may therefore aſcribe many of the evils incident to mankind; for experience ſhews, that men who are born in rude and ſavage climates are naturally of a ferocious diſpoſition; and that a fertile ſoil, which leaves nothing to wiſh for, ſoftens their manners, and inclines them to humanity.

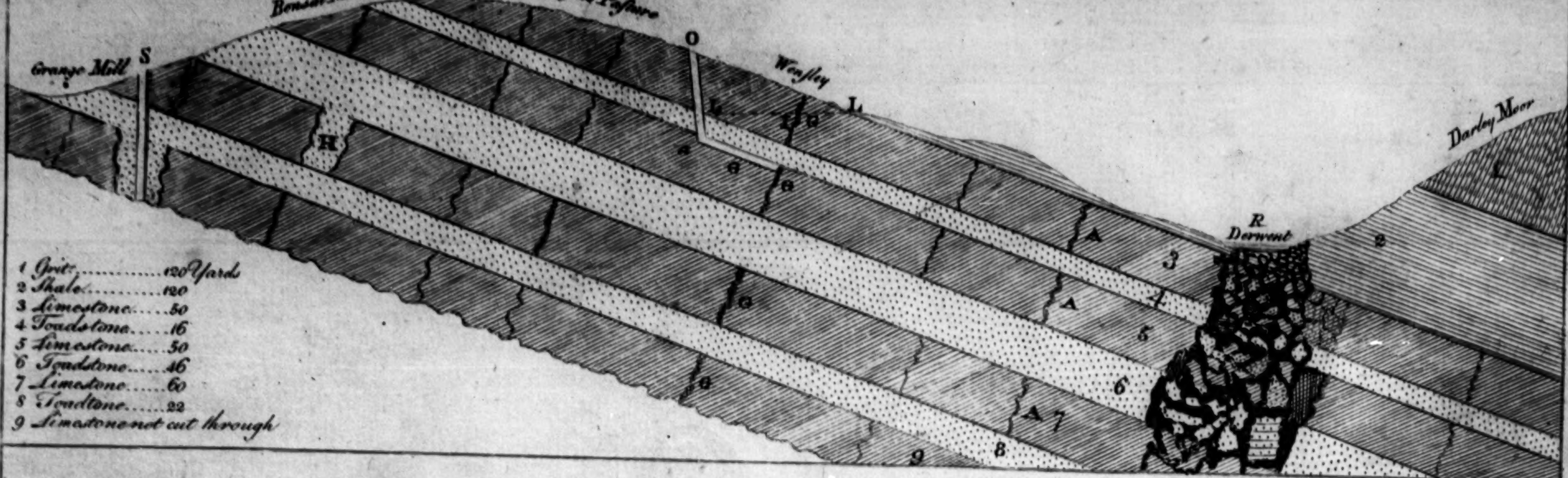
FINIS.

BRITISH MUSEUM 22 OC 75

BRITISH
22 OC 75
MUSEUM

PLATE I

Fig. 6.



1	Grit	120 Yards
2	Shale	120
3	Limestone	50
4	Toadstone	16
5	Limestone	50
6	Toadstone	46
7	Limestone	60
8	Toadstone	22
9	Limestone not cut through	

A Section of the Strata between Grange Mill & Darley Moor.

Publd. as the Act directs May 1.1778.

John Whitehurst del

Fig. 1.

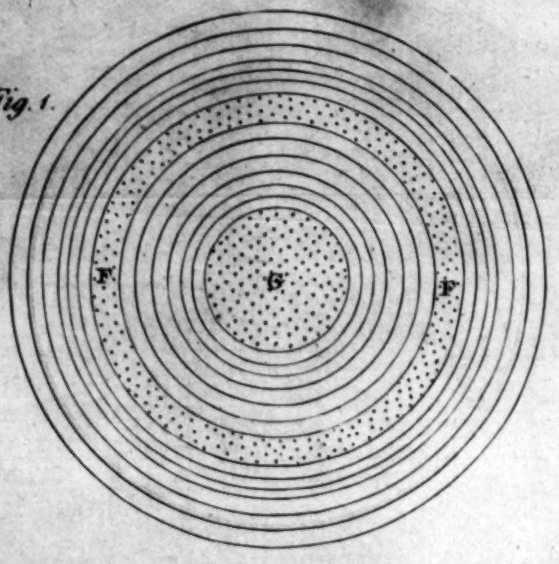


Fig. 2.

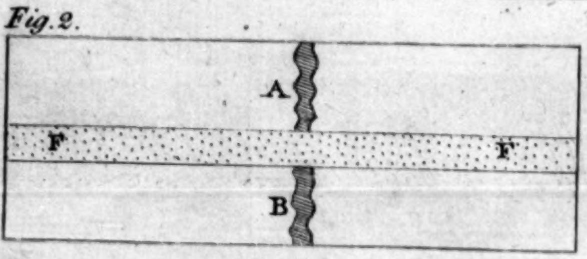


Fig. 3.

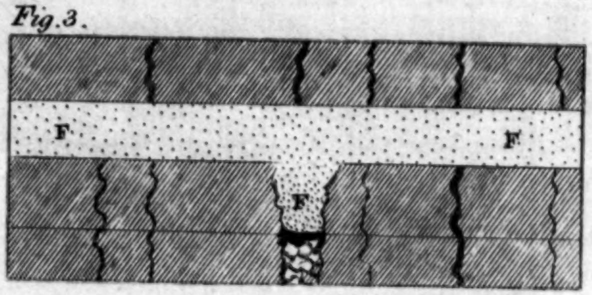


Fig. 4.

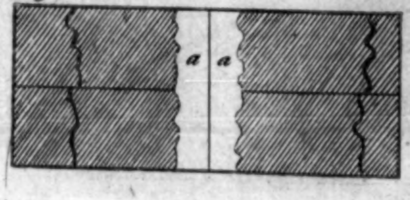
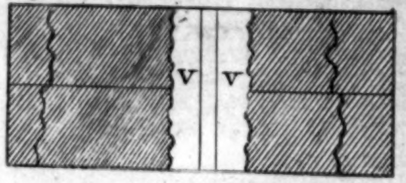
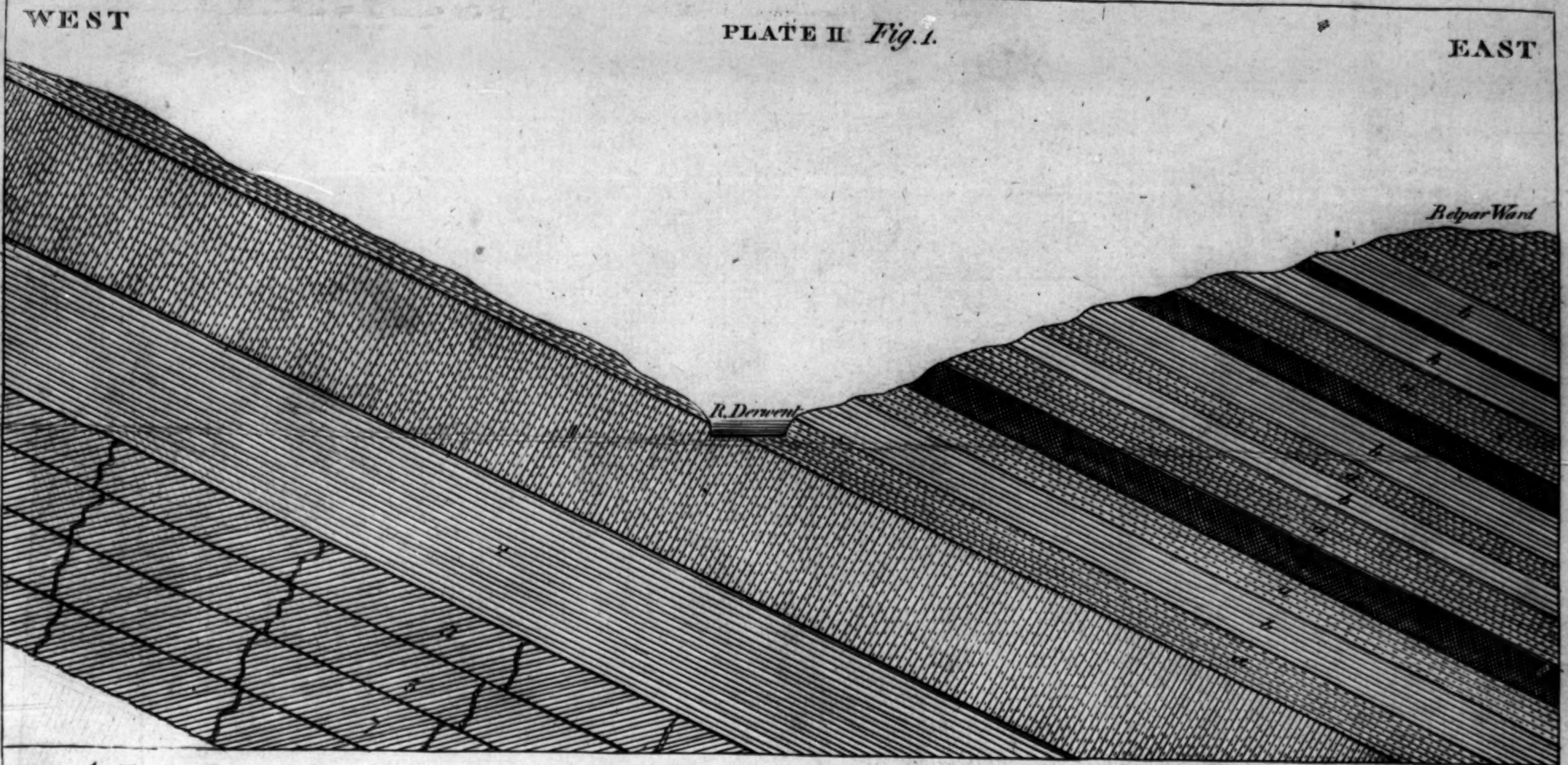


Fig. 5.



John Whitehurst del

PLATE II Fig. 1.



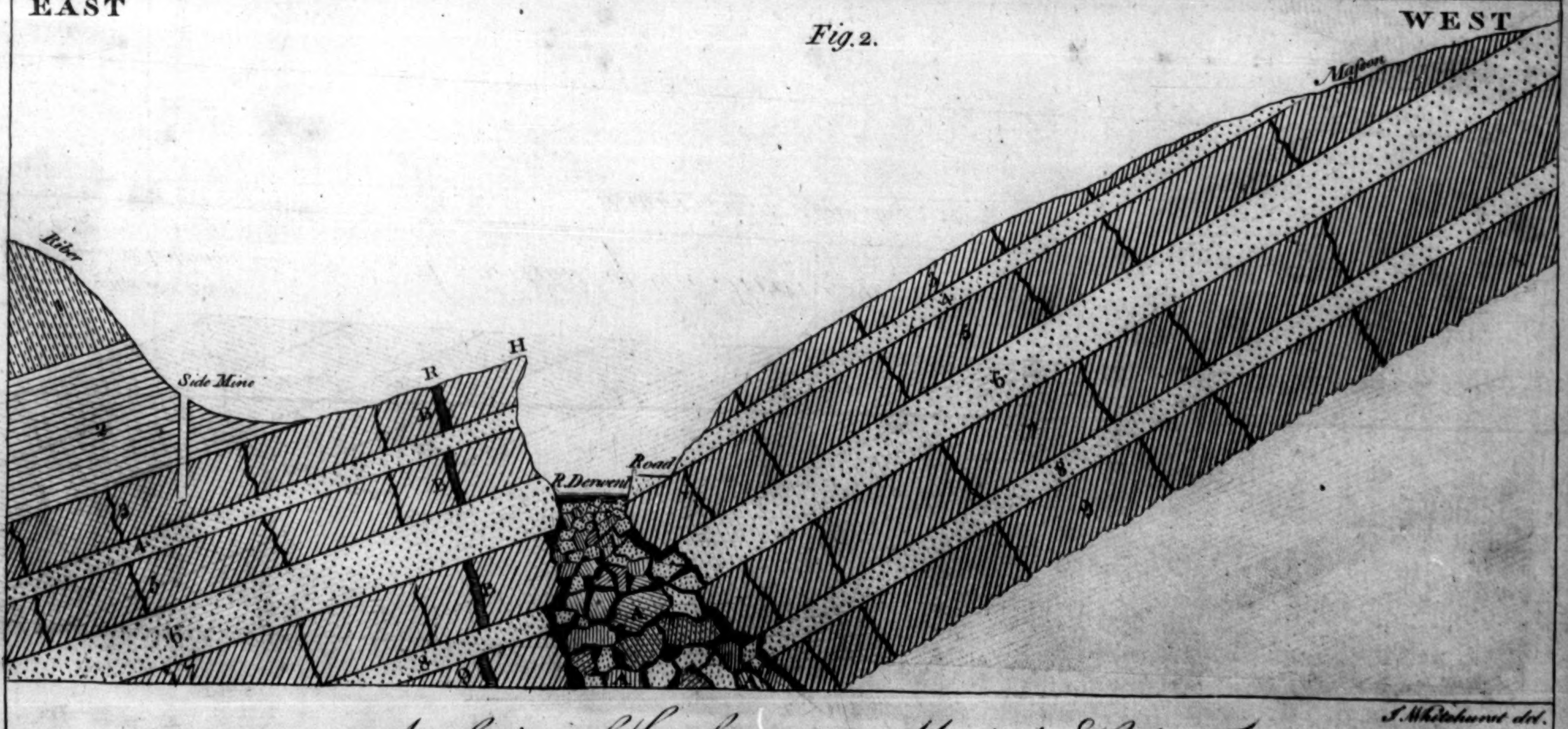
aaaa Argillaceous Stone
bbbb Bind or Indurated Clay
ccc Coal

J. Whitehurst del.

A Section of the Strata near Black-Brook.

Publish'd as the Act directs May 1. 1778.

Fig. 2.

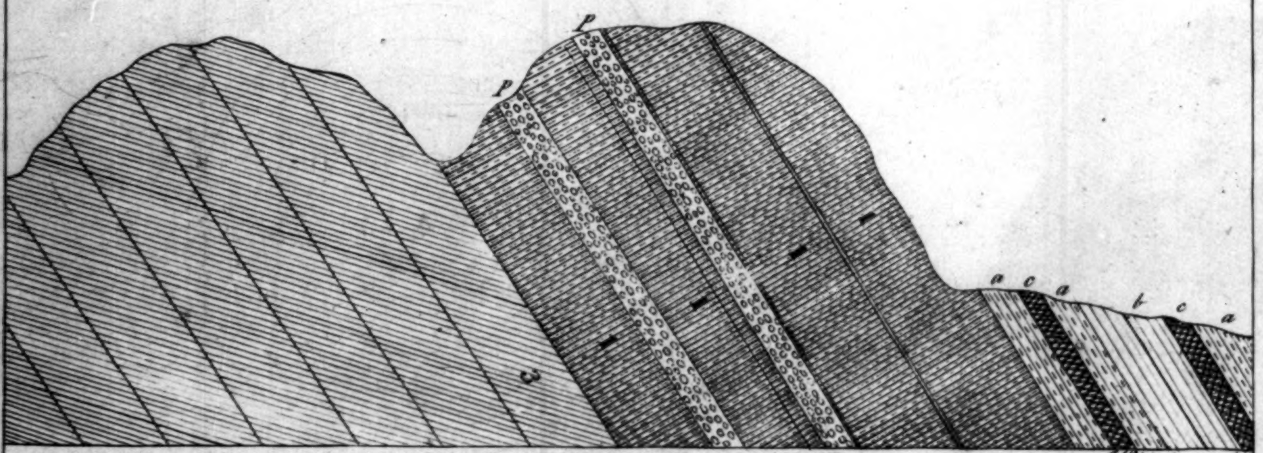


J. Whitehurst del.

A Section of the Strata at Matlock High-Tor.

Publish'd as the Act directs May 1. 1778.

PLATE III *Fig. 3.*



A Section of Lincoln Hill, near Coalbrook Dale, Shropshire.

J Whitehurst del.

Fig. 1.

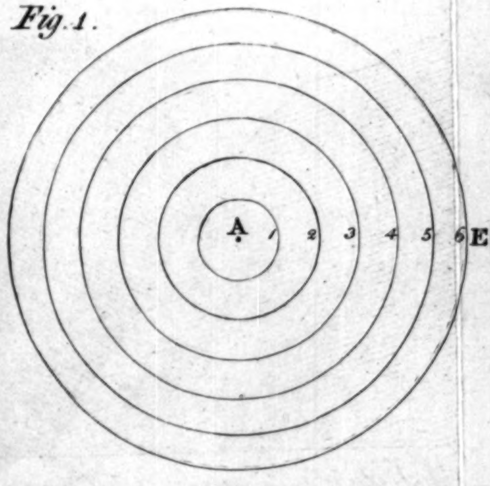


Fig. 2.

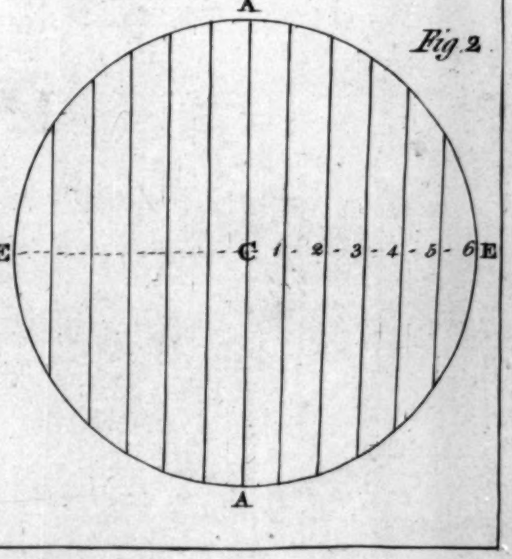
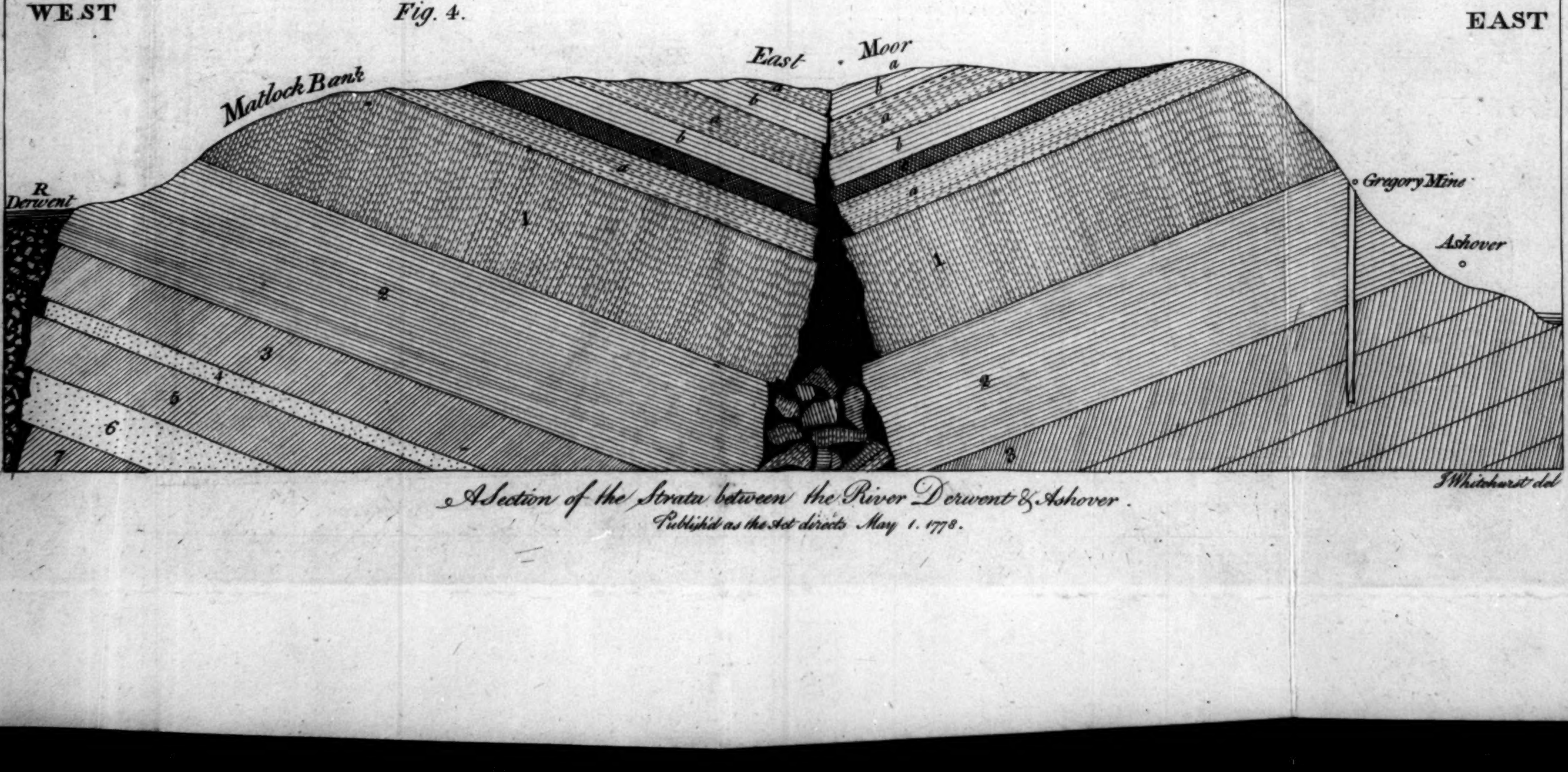


Fig. 4.

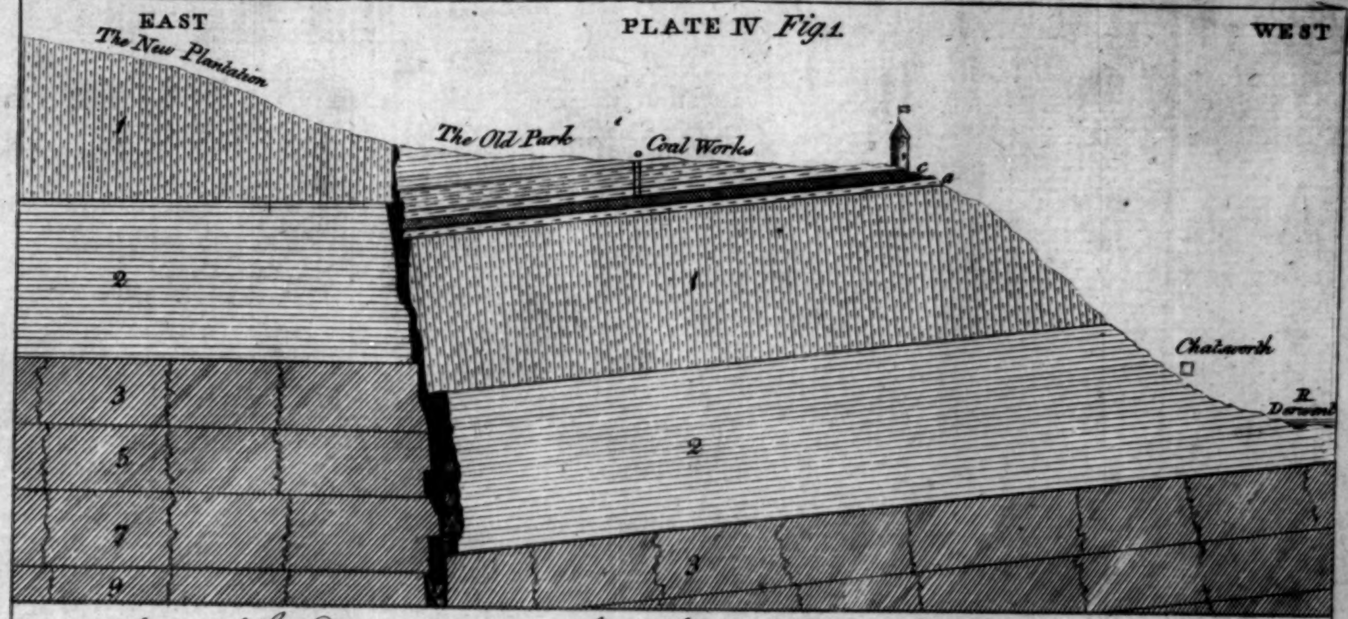


A Section of the Strata between the River Derwent & Ashover.

J Whitehurst del.

Publish'd as the Act directs May 1. 1778.

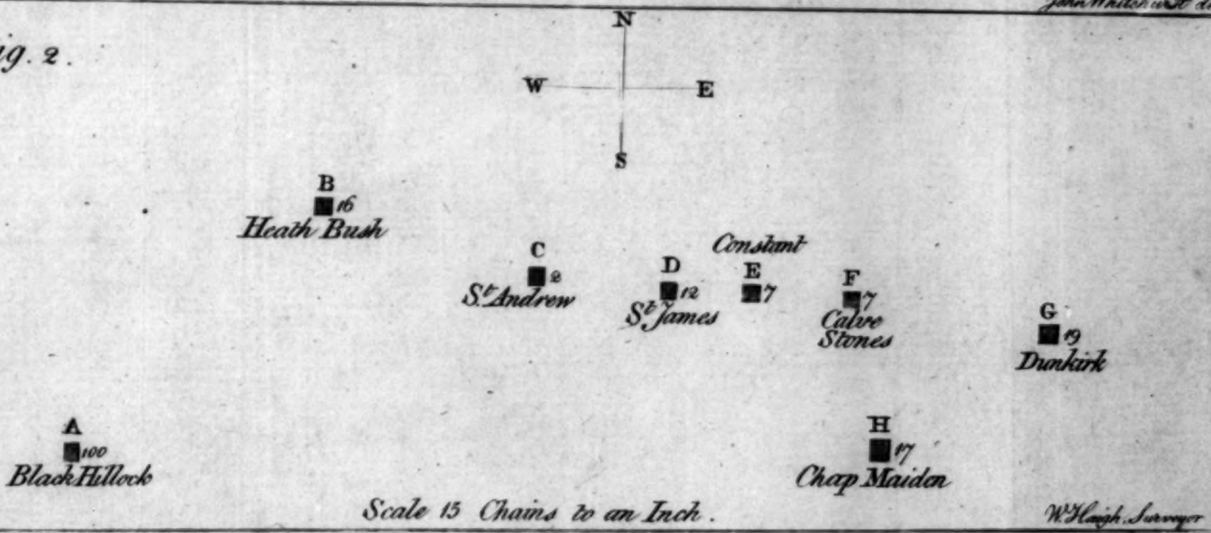
PLATE IV Fig.1.



A Section of the Strata at Chatsworth, from the Old Park to the River Derwent.

John Whitehurst del

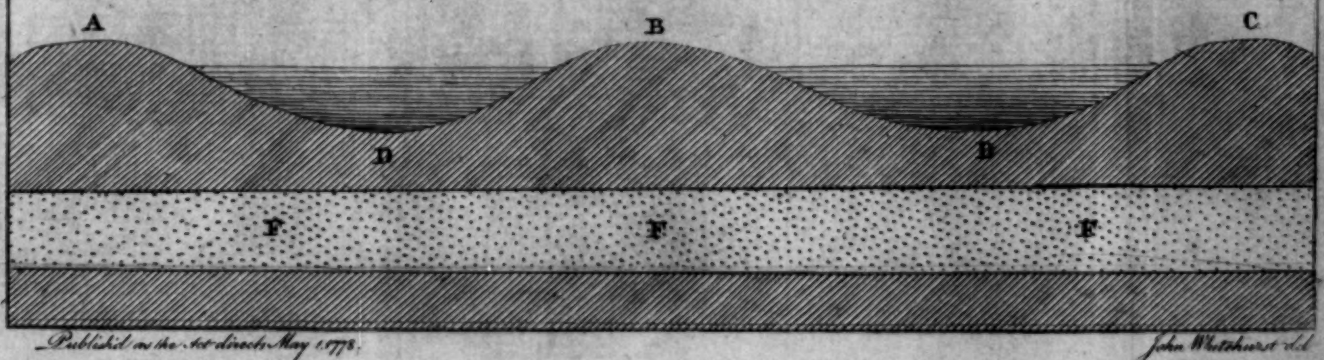
Fig. 2.



A Plan of the Mines on Tideswell Moor.

Fig. 3.

A Section of the Primitive Islands.



Published as the Act directs May 1778.

John Whitehurst del

Begs at B. Castle

B.C. Deep sand — whitish —

Quite on top of Cliff where it is deep is Red

That Red Continues on the high G^d. for 15 M. S.

to Red Bay —

(The Murlock Coal is brought out at low G^d. by sea side)

From Red Bay 2 M. S. is all whitish Brown Sand

then 5 Miles

Section betw^n Red Bay & Carnlough Bay

North of Drumnasole

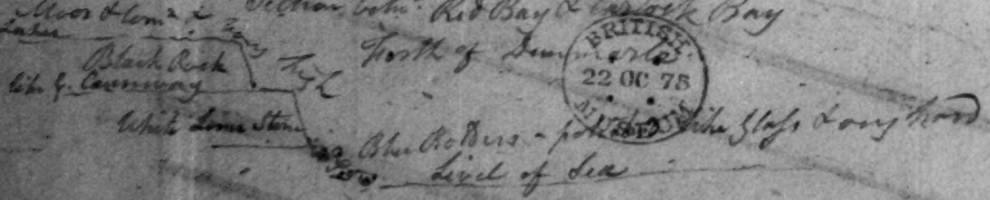


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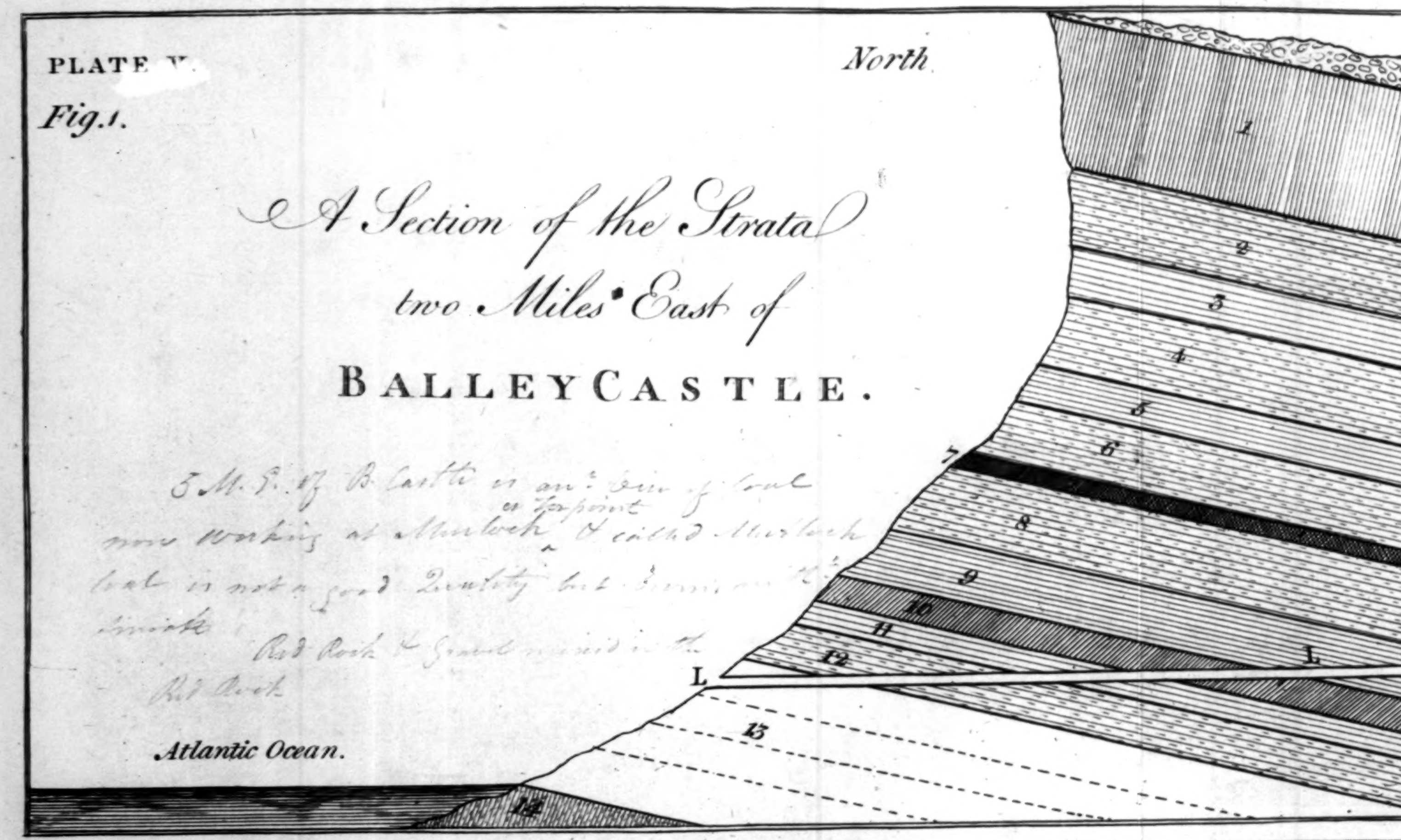
PLATE V.

Fig. 1.



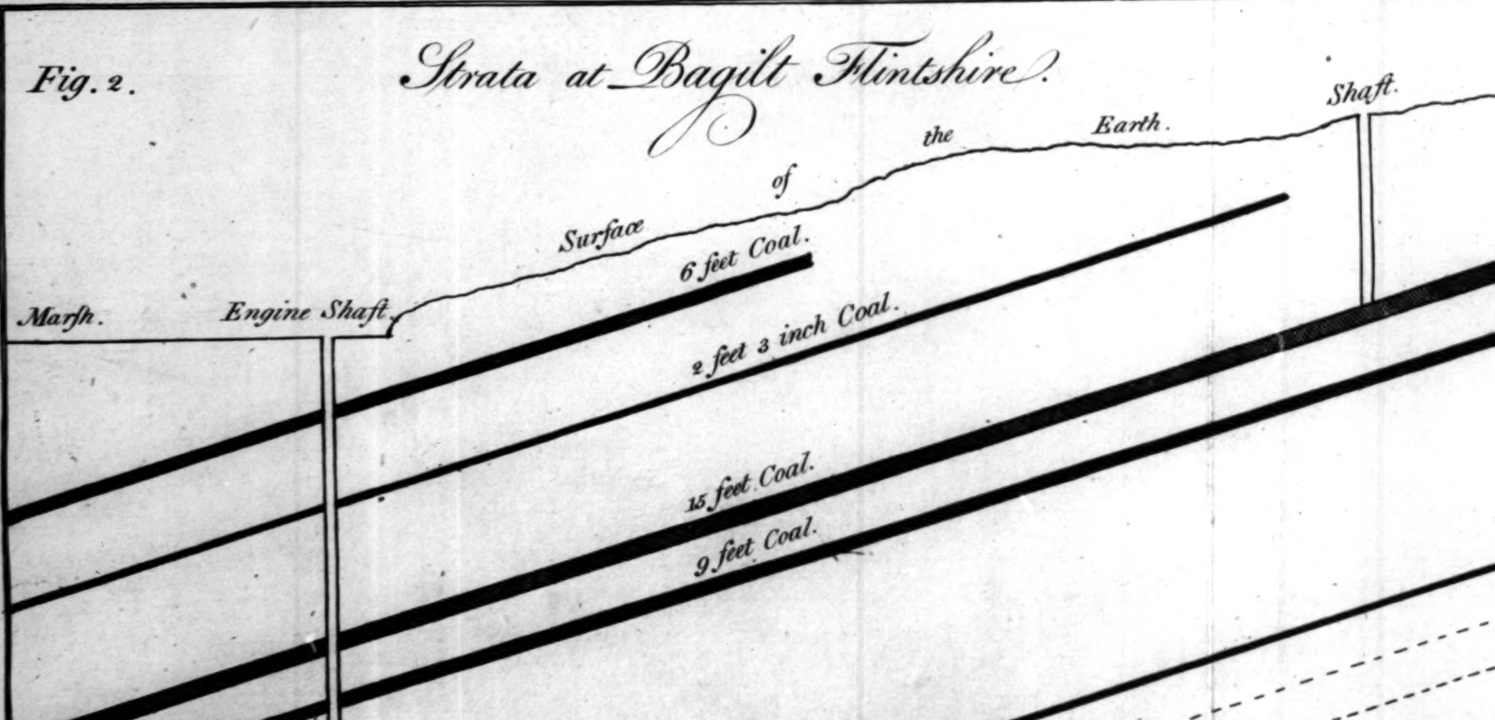
A Section of the Strata two Miles East of BALLEYCASTLE.

5 M. E. of B. Castle is an[illegible] Vein of Coal now working at Murlock or Fairpoint & called Murlock Coal is not a good Quality but burns in [illegible] Smoke

Red Rock & Gravel mixed in the

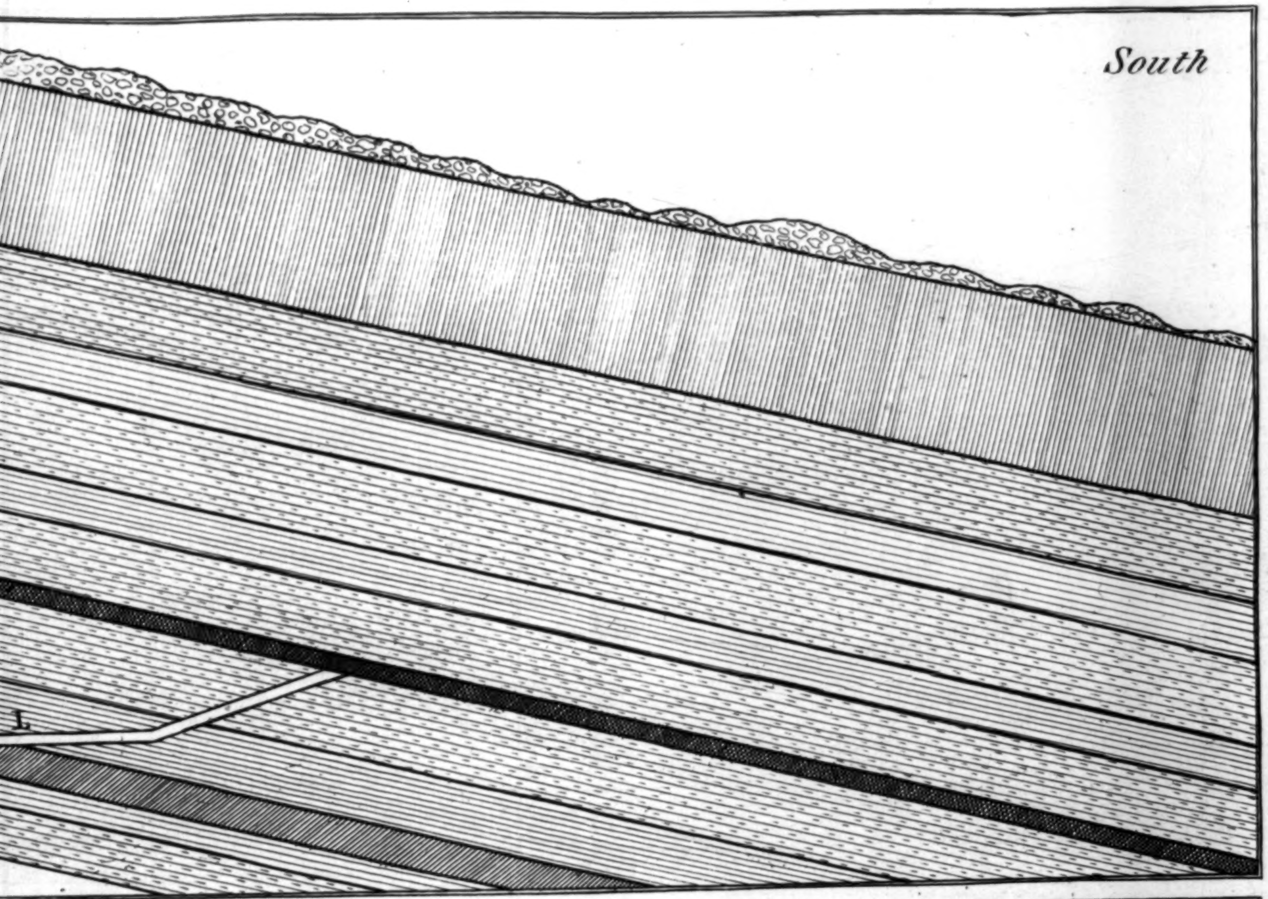
Red Rock

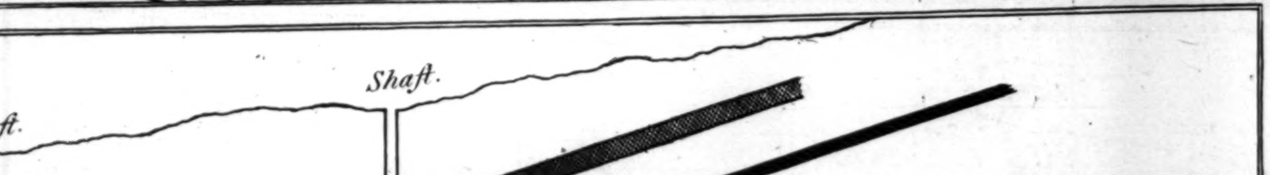
Fig. 2.



Strata at Bagilt Flintshire.

Published by W. Bent, Aug: 10. 1785.





John Whitehurst del.

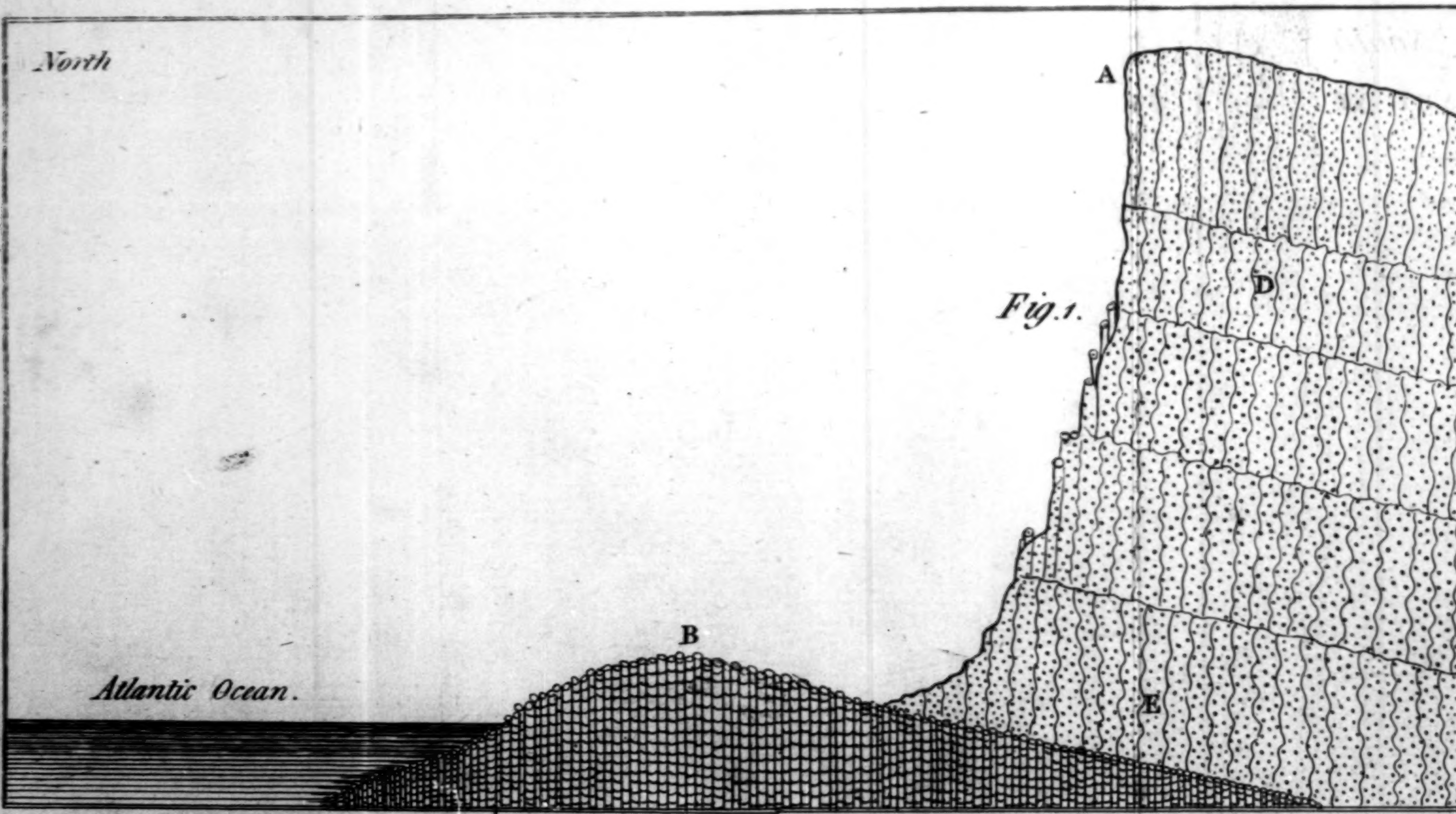
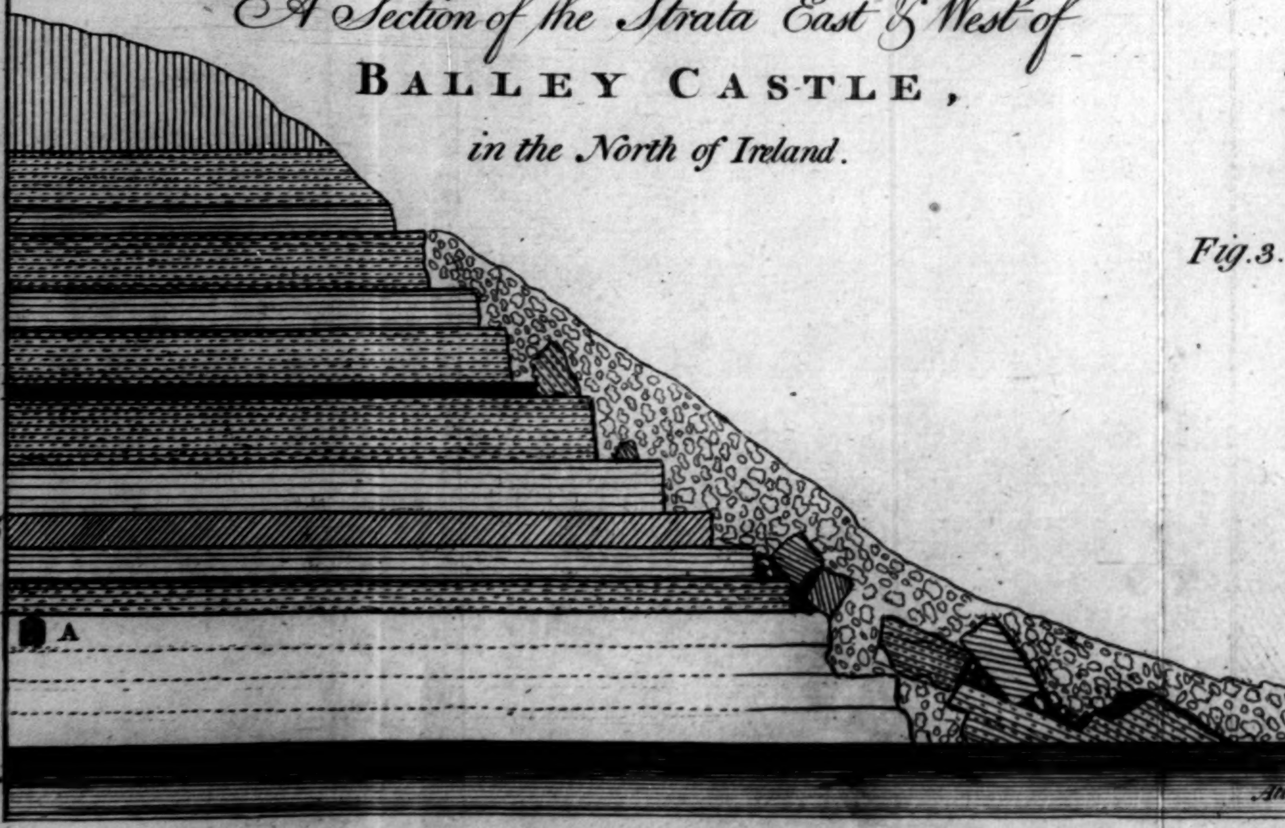


Fig. 1.

Fig. 2.

A Section of the Strata East & West of
BALLEY CASTLE,
in the North of Ireland.



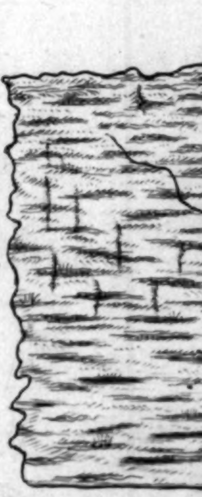
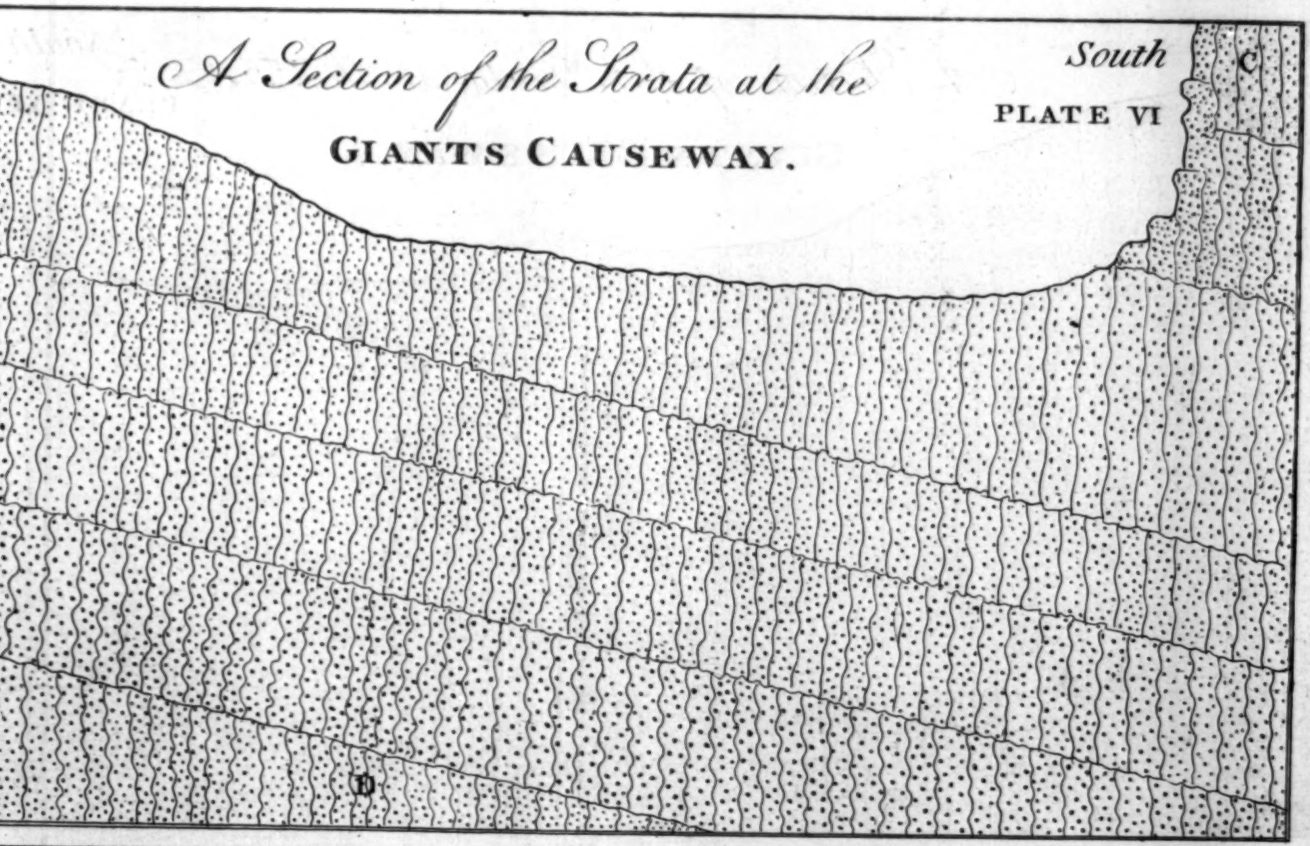


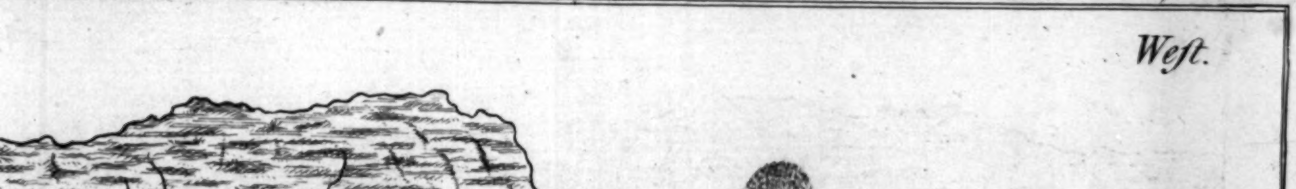
Fig. 3.

Published by W. Bent Aug.

A Section of the Strata at the GIANTS CAUSEWAY.

PLATE VI

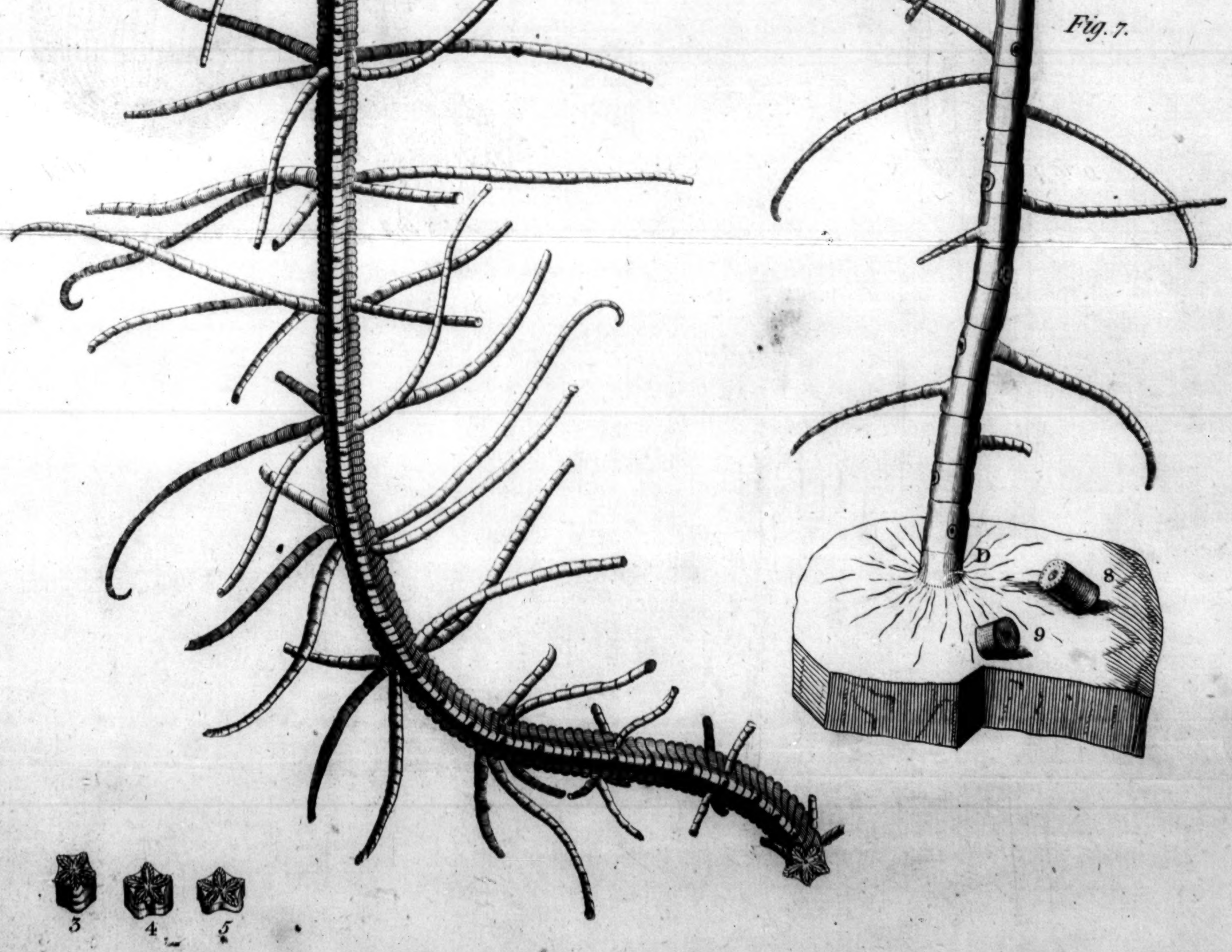




John Whitehurst del.

t Aug. 10. 1785.

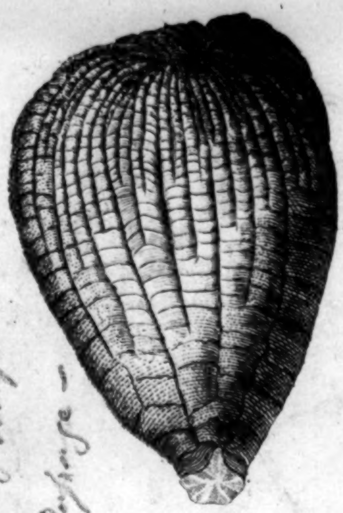
Fig. 7.



Published by W. Bent, Aug. 10, 1785.

PLATE VII.

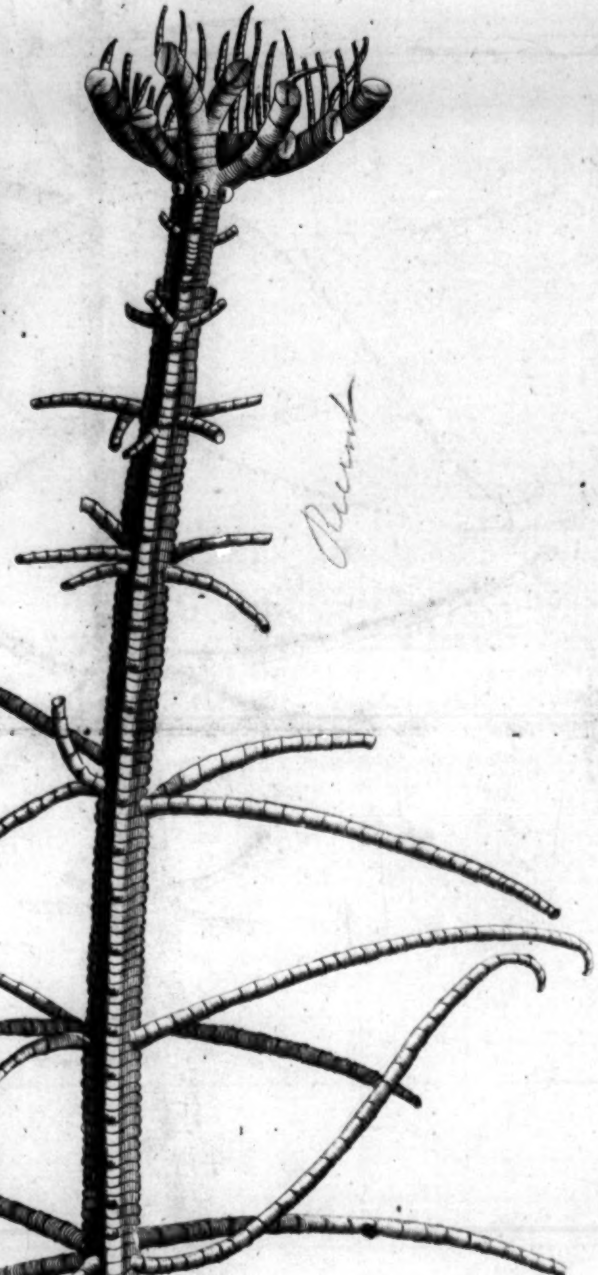
Fig. 1.



Petrified

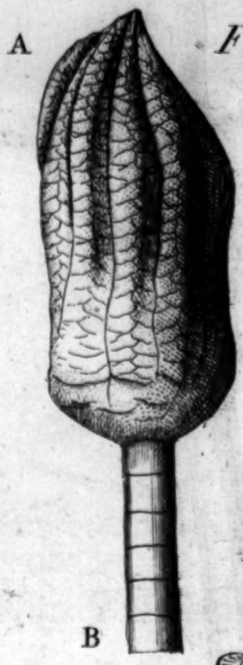
P.n Passage –

Fig. 2.



Recent

Fig. 6.



Petrified

Fig. 7.